PRELIMINARY ASSESSMENT CONTAMINANT LOADINGS FROM ONTARIO BASED LANDFILLS

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for

The Niagara River Improvement Project
Ontario Ministry of the Environment

JULY 1993

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The content and conclusions of this report do not necessarily reflect the views and policies of the Ontario Ministry of Environment and Energy. The data as presented are regarded as valid and can be used in additional assessments.

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1.0 INTRODUCTION

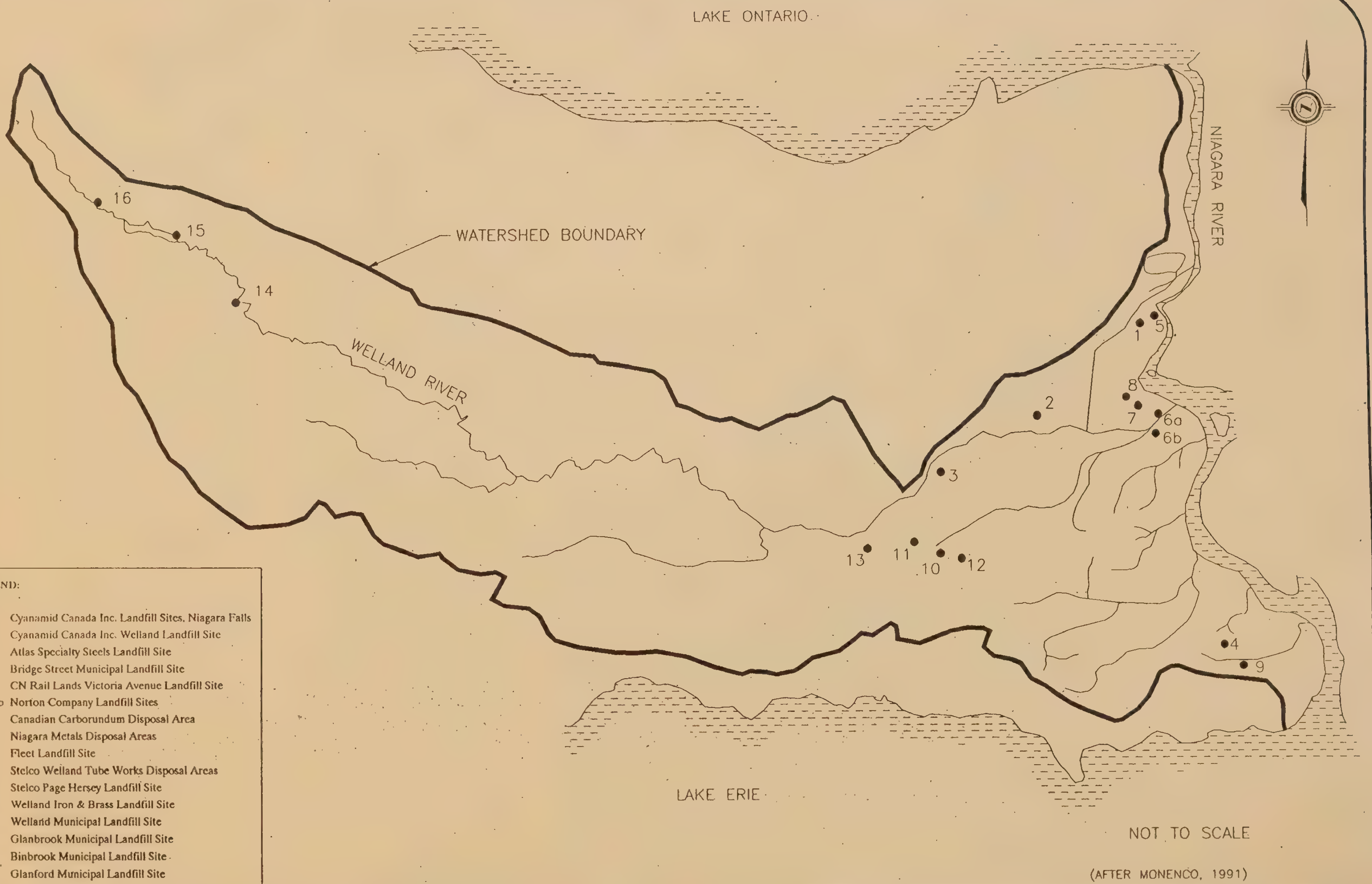
1.1 BACKGROUND INFORMATION

The Ontario Ministry of the Environment and Energy (MOEE), as part of its commitment to the Niagara River Toxic Management Plan, has identified seventeen disposal sites within the Niagara River and Welland River drainage basins as having the potential to contribute contaminants to the Niagara River. These sites, shown in Figure 1-1, include:

Cyanamid Canada Inc. Niagara Falls Landfill Sites, Niagara Falls
Cyanamid Canada Inc. Welland Landfill Site, Welland
Atlas Specialty Steels Landfill Site, Welland
Bridge Street Municipal Landfill Site, Fort Erie
CN Rail Lands Victoria Avenue Landfill Site, Niagara Falls
Norton Company Pell Creek Landfill Site, Chippawa
Norton Company Ort Road Landfill Site, Chippawa
Canadian Carborundum Disposal Area, Niagara Falls
Niagara Metals Disposal Areas, Niagara Falls
Fleet Landfill Site, Fort Erie
Stelco Welland Tube Works Disposal Areas, Welland
Stelco Page Hersey Landfill Site, Welland
Welland Iron & Brass Landfill Site, Welland
Welland Municipal Landfill Site, Welland
Glanbrook Municipal Landfill Site, Glanbrook
Binbrook Municipal Landfill Site, Glanbrook
Glanford Municipal Landfill Site, Mount Hope

Of the seventeen sites, five sites: 1) Cyanamid Canada Inc. Niagara Falls Landfill Sites; 2) Cyanamid Canada Inc. Welland Landfill Site; 3) Atlas Specialty Steels Landfill Site; 4) Bridge Street Municipal Landfill Site; and, 5) CN Rail Lands Victoria Avenue Landfill Site, were identified by the Niagara River Toxics Committee (NRTC) as having significant potential to introduce contaminants to the Niagara River (NRTC, 1984). The other twelve sites were determined to have a lower contaminant loading potential.

The 1991 report titled *Potential Contaminant Loadings To The Niagara River From Canadian Waste Disposal Sites* (Monenco, 1991) presented an evaluation of contaminant loadings to the Niagara River for each of the five landfill sites noted above. The evaluation is based on historical chemical data and a theoretical mass loading calculation. The calculation is attributed to Gradient Corporation and GeoTrans, Inc. who conducted a similar evaluation of landfill sites on the American side of the Niagara River. The Monenco



LEGEND:

1. Cyanamid Canada Inc. Landfill Sites, Niagara Falls
2. Cyanamid Canada Inc. Welland Landfill Site
3. Atlas Specialty Steels Landfill Site
4. Bridge Street Municipal Landfill Site
5. CN Rail Lands Victoria Avenue Landfill Site

6.a & b Norton Company Landfill Sites

7. Canadian Carborundum Disposal Area
8. Niagara Metals Disposal Areas
9. Fleet Landfill Site
10. Stelco Welland Tube Works Disposal Areas
11. Stelco Page Hersey Landfill Site
12. Welland Iron & Brass Landfill Site
13. Welland Municipal Landfill Site
14. Glanbrook Municipal Landfill Site
15. Binbrook Municipal Landfill Site
16. Glanford Municipal Landfill Site

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FIGURE 1-1
LOCATION OF ONTARIO LANDFILL SITES IN THE NIAGARA RIVER AND WELLAND RIVER DRAINAGE BASINS.

report recommended that recent and more comprehensive chemical data be collected for the five landfill sites. In particular, Monenco (1991) recommended that organic parameters omitted in most historical analyses should be included in the data base.

In October 1992, Jagger Hims Limited was retained by the MOEE to reassess the contaminant loadings to the Niagara River from four Ontario Landfill sites under its jurisdiction (excludes CN Rail Lands Victoria Avenue Landfill Site) using data collected at each landfill site in 1993.

1.2 OBJECTIVES AND SCOPE OF WORK

The primary objectives of this study as outlined in the MOEE Request for Proposal (MOE, 1992a) were to :

(a) determine the presence or absence of priority pollutants and NRTC parameters of concern at the four landfill sites under provincial control (excludes CN Rail Lands Victoria Avenue Landfill Site) identified as having significant potential to contribute contaminants to the Niagara River;

(b) reassess the contaminant loadings to the Niagara River following the methodology employed in previous investigations using updated data from the sites; and,

(c) present an update on the status of the seventeen Ontario based landfills identified by the NRTC.

The assessment of the presence or absence of priority pollutants and NRTC parameters of concern at the four landfill sites is based on the collection and analysis of a single set of ground water and surface water quality data for the parameters listed in Table 1-1 for each site in February 1993. The 1993 analytical data were subsequently used to calculate the theoretical contaminant loadings to the Niagara River. The method attributed to Gradient Corporation and GeoTrans, Inc. was used in this calculation.

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TABLE NAME: ANALYSIS PARAMETERS
TABLE NUMBER: 1-1

NRTC PARAMETERS OF CONCERN (1)	PRIORITY POLLUTANT PARAMETERS (2)				
	Volatile Organics (EPA 624)	Semi Volatile Organics (EPA 625)		Pesticides & PCBs (EPA 608)	Inorganics
Benzo(a)anthracene	Benzene	Acenaphthylene	2,6-Dichlorophenol	Aldrin	Antimony
Benzo(k)fluoranthene	Bromodichloromethane	Acenapthene	2,4,6-Trichlorophenol	Endosulfan I	Beryllium
Benzo(b)fluoranthene	Bromoform	Anthracene	2,4-Dimitrophenol	Endrin	Cadmium
Benzo(a)pyrene	Bromomethane	2,3,4,5-Tetrachlorophenol	3,3-Dichlorobenzidine	Heptachlor Epoxide	Chromium
Chrysene	Carbon Tetrachloride	2,3,4,6-Tetrachlorophenol	2,4-Dinitrotoluene	Alpha-BHC	Copper
Tetrachloroethene	Chlorobenzene	1,3-Dichlorobenzene	2,6-Dinitrotoluene	4,4-DDD	Lead
Chlordane	Chloroethane	1,2-Dichlorobenzene	Hexachlorobutadiene	Delta-BHC	Nickel
DDT-metabolites	Trichlorofluoromethane	1,4-Dichlorobenzene	Diphenylether	Endosulfan II	Silver
PCB's (total)	Vinyl Chloride	1,2,4-Trichlorobenzene	Indole	Beta-BHC	Thallium
Dieldrin	o-xylene	Dibenzo(ah)anthracene	Camphene	4,4-DDE	Zinc
Mercury	1,2-Dichlorobenzene	Fluoranthene	o-Cresol	Endosulfan Sulfate	Cyanide
Mirex	Styrene	Fluorene	2,4-Dimethyphenol	Heptachlor	
Octochlorostyrene	1,3-Dichlorobenzene	Indeno(1,2,3-cd)pyrene	4-Chloro-3-Methylphenol	Methosychlor	
Dioxin	1,4-Dichlorobenzene	Naphthalene	2,4,5-Trichlorophenol		
(2,3,7,8-TCDD)	1,1-Dichloroethane	Phenanthrene	4-Nitrophenol		
Hexachlorobenzene	1,2-Dichloroethane	Pyrene	4,6-Dinitro-2-methylphenol		
Arsenic	1,1-Dichloroethane	Biphenyl	bis(2-ethylhexyl)phthalate		
Lead	trans-1,2-Dichloroethylene	2-Methylnaphthalene	4-Bromopheny-phenylether		
Toxaphene	cis-1,2-Dichloroethylene	1-Methylnapthalene	bis(2-Chloroethoxy)methane		
	Chloroform	2-Chloronapthalene	bis(2-Chloroethyl)ether		
	Chloromethane	1-Chloronapthalene	bis(2-Chloroisopropyl) ether		
	Dibromochloromethane	5-Nitroacenaphthene	4-Chloropheny-phenylether		
	Methylene Chloride	Perylene	Hexachloroethane		
	Ethylene Dibromide	Phenol	Nitrosamines		
	1,1,2,2-Tetrachloroethane	m-,p-Cresol	N-nitrosodiphenylamine		
	Tetrachloroethene	2,4-Dichlorophenol	N-nitroso-di-n-propylamine		
	Toluene	2,3,5-Trichlorophenol			
	1,1,1-Trichloroethane	2,3,4-Trichlorophenol			
	1,1,2-Trichloroethane	2,3,5,6-Tetrachlorophenol			
	Trichloroethene	Pentachlorophenol			
	1,2-Dichloropropane	Di-n-butylphthalate			
	cis-1,3-Dichloropropene	Butylbenzylphthalate			
	trans-1,3-Dichloropropene	Di-n-octylphthalate			
	Ethylbenzene	2-Chlorophenol			
	m,p-xylenes				

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Notes:
1) List provided by MOEE (personal communication, 1993).
2) Modified from list presented in Monenco (1991).

The status of the remaining thirteen landfill sites (includes CN Rail Lands Victoria Avenue Landfill Site) in the Niagara River and Welland River drainage basins was updated through telephone communications with appropriate personnel from the municipal and public sectors and, where available, the review of hydrogeologic reports prepared by others and made available to Jagger Hims Limited by the MOEE. No confirmatory investigations were undertaken by Jagger Hims Limited.

2.0 STUDY METHODOLOGY

2.1 SAMPLING PLAN DEVELOPMENT

2.1.1 Selection of Water Sampling Locations

The selection of monitoring wells and surface water sampling stations for this study was based on information presented in reports available for the sites and provided to Jagger Hims Limited by the MOEE. Criteria used in the selection of the sampling stations include:

- existing monitoring wells and surface water sampling stations which are accessible;
- the sampling station should be capable of providing samples which are representative of landfill leachate quality, upgradient water quality or downgradient water quality; and,
- the downgradient sampling stations should historically have provided samples that illustrate elevated chemical concentrations in comparison to samples collected upgradient of the landfill.

Synopses of site conditions, including the geology, hydrogeology and site instrumentation at each landfill site from recent reports for the sites, and observations made during the field sampling program, are included in Appendix A for information purposes.

In general, three monitoring wells and one surface water sampling station were selected per site to provide representative information on: 1) downgradient water quality; 2) leachate quality; or, 3) background (upgradient) water quality. However, it was necessary at two of the sites to include additional stations to accommodate complexities in the physical setting and ground water flow regime. The locations and rationale for selection of the sampling stations are listed by site in Table 2-1 and summarized on a site-by-site basis in the following paragraphs.

Cyanamid Canada Inc. Niagara Falls Landfill Sites - The hydrogeology of the Cyanamid Canada Inc. Niagara Falls Landfill Sites as defined by Gartner Lee Limited (1988) is complex. For descriptive purposes four contaminant migration pathways to the Niagara River have been identified (Gartner Lee Limited, 1988). These include:

1) ground water movement through the bedrock to the Queenston-Chippawa Power Canal and subsequently surface water flow to the Niagara River;

2) ground water flow through the overburden to the Queenston-Chippawa Power Canal and subsequently surface water flow to the Niagara River;

3) ground water movement through the overburden directly to the Niagara River; and,

4) bedrock ground water movement through the bedrock to the Niagara River via the buried St. Davids Gorge.

A total of six monitoring wells and a single surface water station were sampled. Specifically included are two overburden and two bedrock wells positioned along the identified flow pathways downgradient of the waste disposal areas, and overburden and bedrock wells located upgradient of the waste. A sampling station capable of providing information on leachate was not identified. From a review of available historical water quality data summarized by Gartner Lee Limited (1990), it would appear that the waste is spatially variable, which in turn affects the leachate quality. Consequently no single station is likely to provide representative samples. The selected surface water sampling station is located at a spring which discharges downstream from the waste disposal areas at the base of the

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TABLE NUMBER: 2-1

LANDFILL SITE	LOCATION	SCREENED UNIT	DEPTH (m)	HISTORIC CHEMISTRY AVAILABLE	BASIS FOR SELECTION
Cyanamid Canada Inc. Niagara Falls Landfill Sites	C1-5-I	Dolostone	17.3	yes	- Located near downgradient site boundary to buried St. Davids Gorge. - Based on Monenco 1991 and Gartner Lee Limited findings, the majority of contaminant loading to the Niagara River from the buried St. Davids Gorge is via bedrock. - Historical water quality data is representative of average contaminant loading to Niagara River from this migration pathway.
	B1-10-II	Silt Till	9.84	yes	- Located near downgradient boundary in area where majority of contaminant loading to the Niagara River is directly via overburden. - Historical water quality data is representative of average contaminant loading to Niagara River from this migration pathway.
	A1-8-I	Dolostone	17.7	yes	- Located near downgradient boundary to Queenston-Chippawa Power Canal. - Based on Monenco 1991 and Gartner Lee Limited findings, significant loadings to the Niagara River are via bedrock ground water discharging to the Queenston-Chippawa Power Canal in this area.
	C1-4-II	Silty Clay	12.00	yes	- Located near downgradient boundary to Queenston-Chippawa Power Canal. - Based on Monenco 1991 and Gartner Lee Limited findings, significant loadings to the Niagara River are via overburden ground water discharging to the Queenston-Chippawa Power Canal in this area.
	BG1-I	Bedrock	17.37	yes	- Located upgradient of landfill sites - Historical water quality data is representative of average background concentrations in bedrock.
	BG1-II	Overburden	11.08	yes	- Located upgradient of landfill sites - Historical water quality data is representative of average background concentrations in overburden.
	SW16	Surface Water		yes	- Spring located downstream of sites at base of Whirlpool Gorge.
Cyanamid Canada Inc. Welland Landfill Site	5-IV	Clayey silt to silty clay	5.5	yes	- Located near downgradient boundary adjacent to Welland River. - Historical chemistry representative of average observed concentrations.
	5-I	Dolomitic Limestone	23.16	yes	- Located near downgradient boundary adjacent to Welland River. - Historical chemistry representative of average observed concentrations.
	23-I	Sludge	8.15	yes	- Located in sludge basin. - Capable of providing samples representative of leachate quality - Located upstream of site on Thompsons Creek
	C1	Surface Water		no	- Location of creek bed monitor sampled previously.
	C9	Surface Water		no	- Located downstream of site on Thompsons Creek. - Location of creek bed monitor sampled previously.
Atlas Specialty Steels Landfill Site	AS12	Silty Clay Berm	5.26	no	- Monitoring well located near downgradient site boundary.
	AS13	Silty Clay Berm	5.38	no	- Monitoring well located near downgradient site boundary.
	AS14	Silty Clay Berm	5.36	no	- Monitoring well located near downgradient site boundary.
	SS3	Surface Water		yes	- Located at surface water outflow from site.
Bridge Street Municipal Landfill Site	OW17-6	Sandy silt (below waste)	5.8	yes	- Located in Landfill.
	OW23-5	Silty Clay	4.5	yes	- Located in overburden downgradient of landfill. - Historical chemistry representative of downgradient average concentrations.
	OW29-14	Dolostone	14.0	yes	- Located in bedrock downgradient of landfill. - Historical chemistry representative of downgradient average concentrations.
	S4	Surface Water	---	yes	- Downstream of site on Miller Creek; north of Bowen Road.

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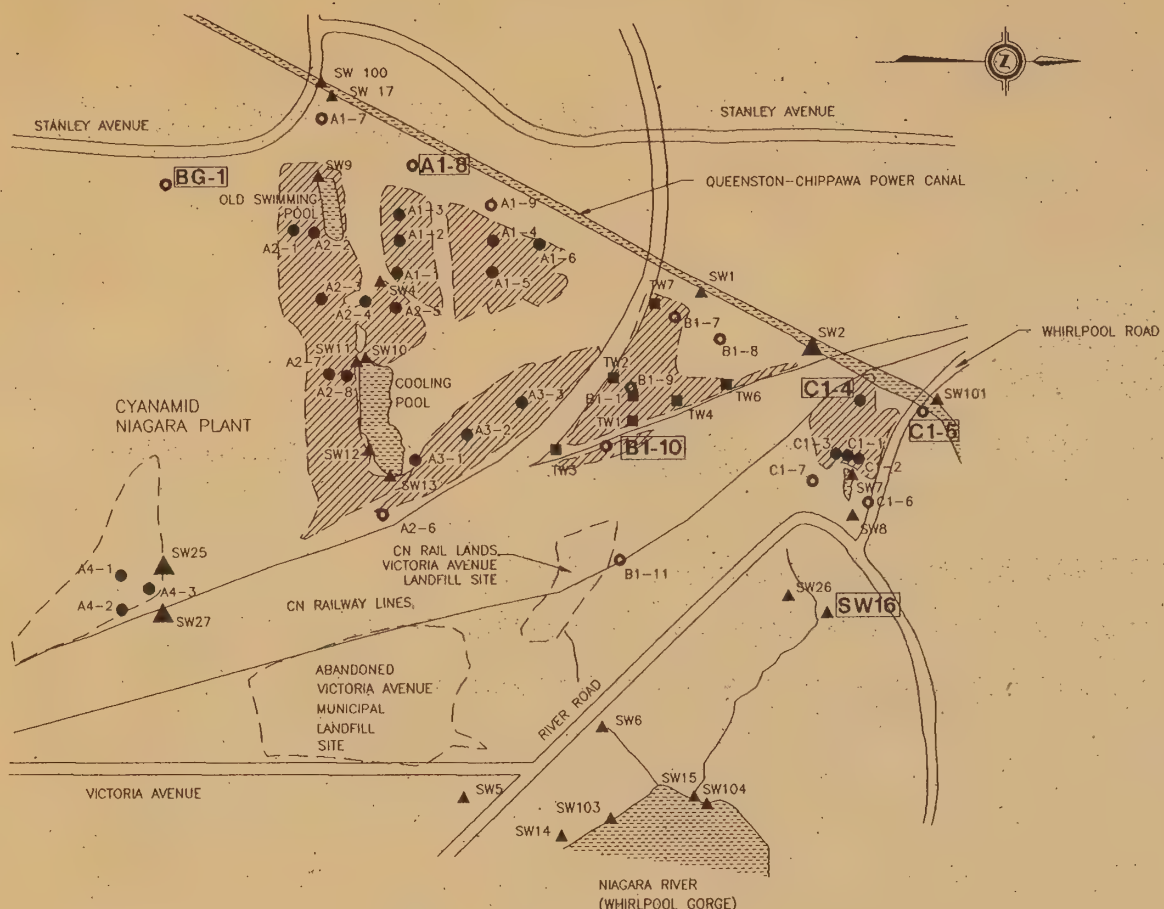
Niagara River Gorge. The sampling stations are identified in Table 2-1 and their locations are illustrated in Figure 2-1.

Cyanamid Canada Inc. Welland Landfill Site - Three ground water monitoring wells and two surface water sampling stations were selected at the Cyanamid Canada Inc. Welland Landfill Site (Figure 2-2). Included are downgradient bedrock and overburden monitoring wells (5-I and 5-IV, respectively) adjacent to the Welland River, and leachate monitoring well (23-I). A background (upgradient) monitoring well was not selected. The potential presence of water table mounding within the waste and the proximity of the monitoring wells north of the sludge basins (i.e. upgradient) made selection of a representative background monitoring well tenuous at best. Two surface water sampling stations along Thompson Creek, located adjacent to existing creek bed ground water monitors C1 and C9, were selected to provide information on surface water quality upstream and downstream of the landfill. It should be noted that the downstream location (C9) also corresponds to a Municipal and Industrial Strategy for Abatement (MISA) data collection station.

Atlas Specialty Steels Landfill Site - Three overburden monitoring wells located downgradient of the waste disposal area and one surface water station were sampled at the Atlas Specialty Steels Landfill Site. The monitoring wells are identified in Table 2-1 and their locations are illustrated in Figure 2-3.

Monitoring wells have not been completed in either the bedrock or the waste at this site and it was therefore not possible to sample bedrock ground water nor collect a sample of leachate as part of this study. It should also be noted that it was necessary to modify the sampling program in the field as a consequence of well availability. As originally proposed in the *Draft Sampling Plan For Ontario Based Landfills* (Jagger Hims Limited, 1992), the ground water sampling stations selected based on available information for this site included one upgradient monitoring well (AS5) and two downgradient monitoring wells (AS1 and AS3). During the subsequent site visit (February 3, 1993) monitoring wells AS5 and AS1 could not be located and were assumed to have been destroyed. In addition, monitoring well AS3 was blocked about 0.5 metres below ground surface and could not be sampled.



LEGEND

A1-8 1993 SAMPLING LOCATION

CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES

PHASE II (a) GROUND WATER MONITORING WELL LOCATION

PHASE II (b) GROUND WATER MONITORING WELL LOCATION

SURFACE WATER SAMPLING POINT

MINISTRY OF THE ENVIRONMENT BOREHOLE

APPROXIMATE LIMIT OF WASTE AND/OR FILL AREA

SURFACE WATER

SCALE

0 200 400 m

1:12,500

(MODIFIED FROM GARTNER LEE LIMITED, 1988)

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FIGURE 2-1

SITE PLAN
CYANAMID CANADA INC. NIAGARA FALLS
LANDFILL SITES

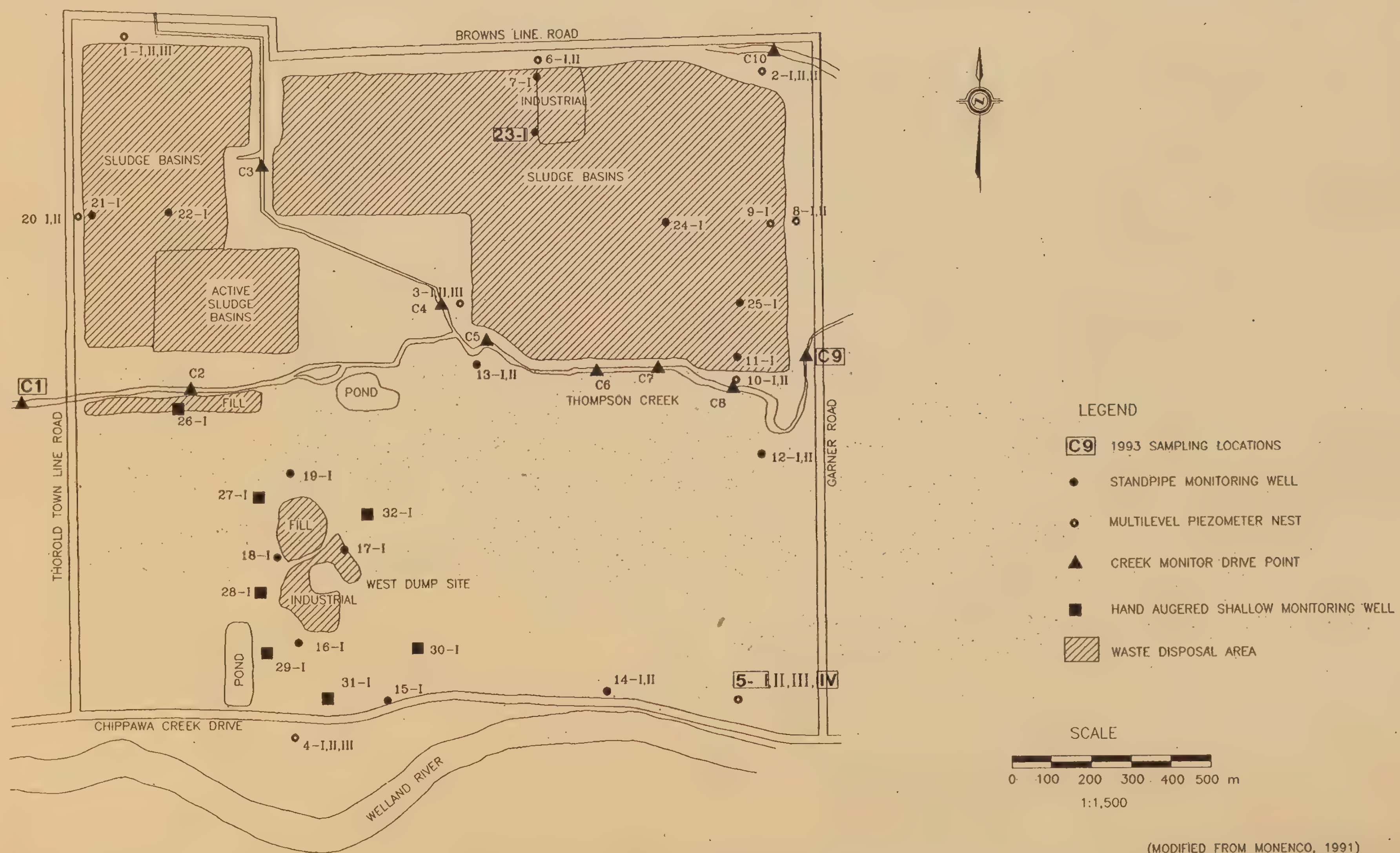

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FIGURE 2–2
SITE PLAN
CYANAMID CANADA INC.
WELLAND LANDFILL SITE

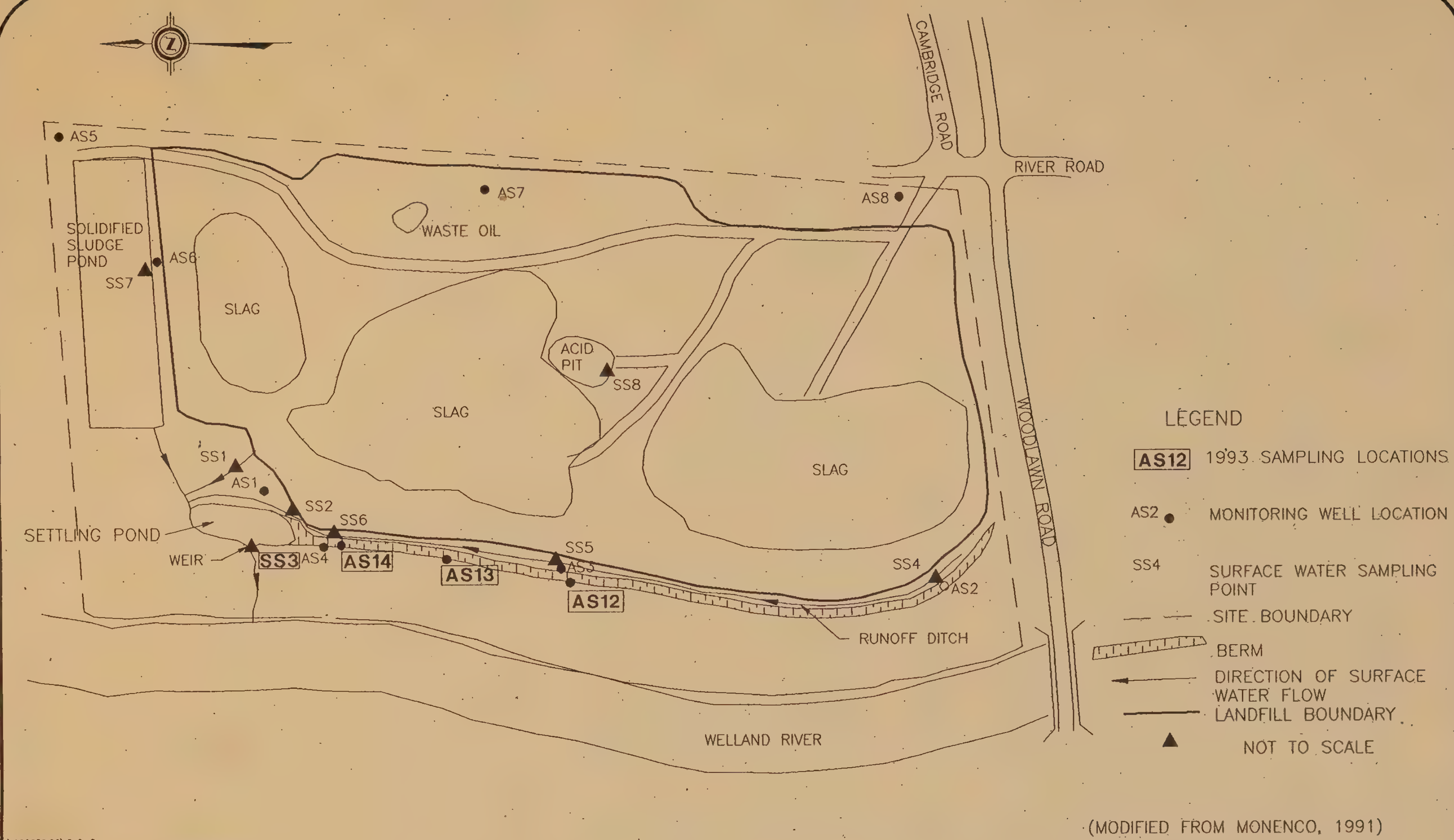

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FIGURE 2-3
SITE PLAN
ATLAS SPECIALTY STEELS
LANDFILL SITE

Bridge Street Municipal Landfill Site - The sampling stations at the Bridge Street Municipal Landfill Site included one downgradient overburden monitoring well, one downgradient bedrock monitoring well and one monitoring well completed immediately below the refuse (Figure 2-4). Based on a review of historical data for the site the existing monitoring wells appeared to be hydraulically downgradient of the waste disposal area and do not appear capable of providing samples representative of background (upgradient) water quality. Therefore, no background water samples were collected. A single surface water sampling station (S4a) along Miller Creek was established and sampled. As originally proposed in the *Draft Sampling Plan for Ontario Based Landfills* (Jagger Hims Limited, 1992), surface water sampling station S3 was to be sampled. At the time of sampling, however, location S3 was frozen and could not be sampled.

2.1.2 Selection of Analytical Program

The analytic parameter list used for this study was selected based on a review of the recommendations in Monenco's 1991 report titled *Potential Contaminant Loadings To The Niagara River From Canadian Waste Disposal Sites* and available reports for the individual sites. The process followed to select the parameter list included a review of the available chemical data base from each site for the NRTC parameters of concern as defined by the MOEE (MOEE personal communication 1993) and the parameters identified in the priority pollutant list provided in Monenco's 1991 report. The decision process is summarized in Figure 2-5. The parameters are listed in Table 1-1.

All sites were sampled for the NRTC parameters of concern and the parameters on the Priority Pollutant List (volatile organic compounds, semi volatile acid/base/neutral extractable compounds, PCBs and pesticides, and inorganics). General chemistry samples (pH, conductivity, chloride, sulphate, alkalinity, calcium, sodium, potassium, magnesium, and nitrogen compounds) were also analysed.

2.2 FIELD METHODS

A field program consisting of well purging, and ground water and surface water sample collection was conducted by Jagger Hims Limited personnel between February 3, 1993 and

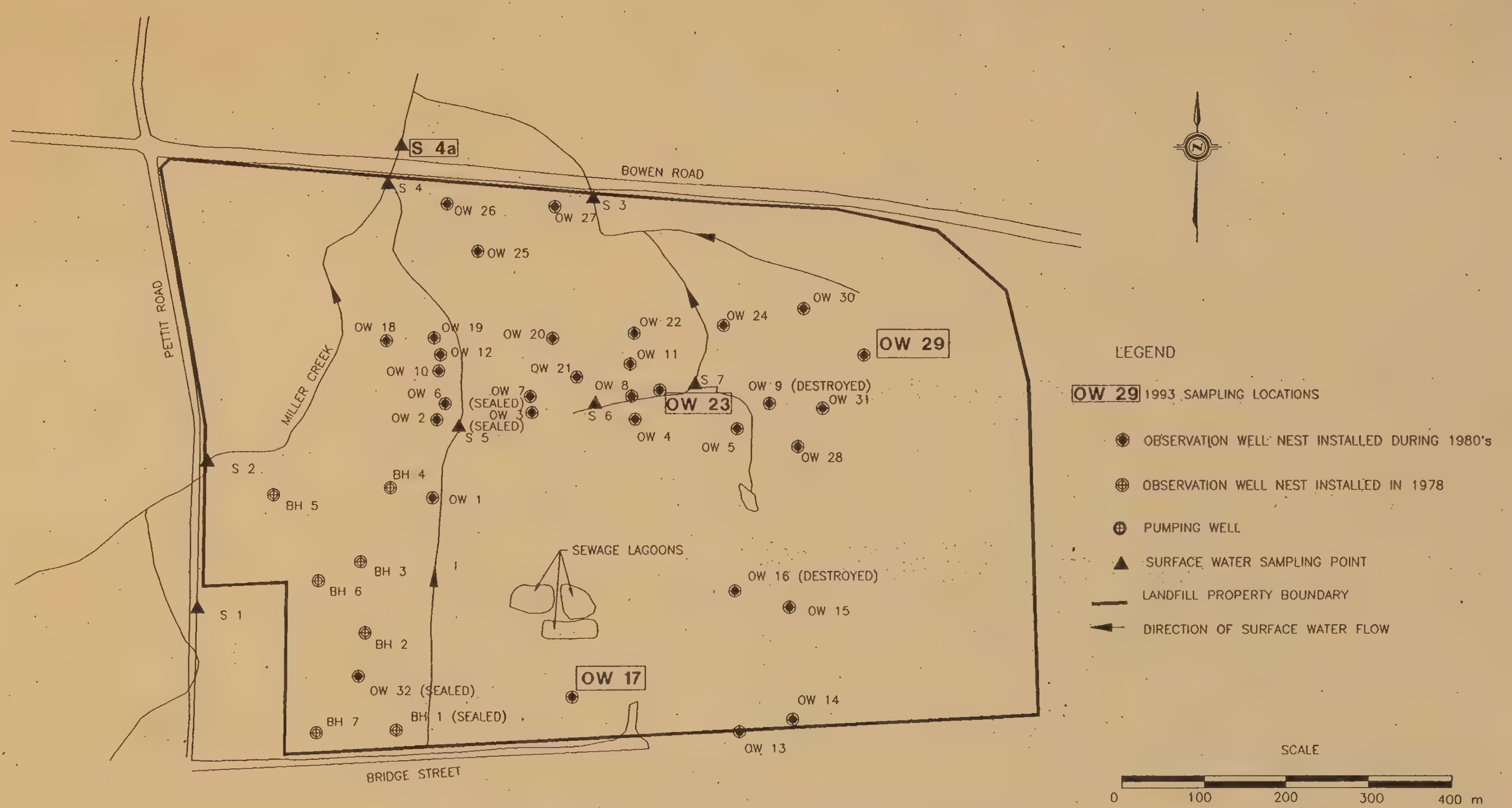

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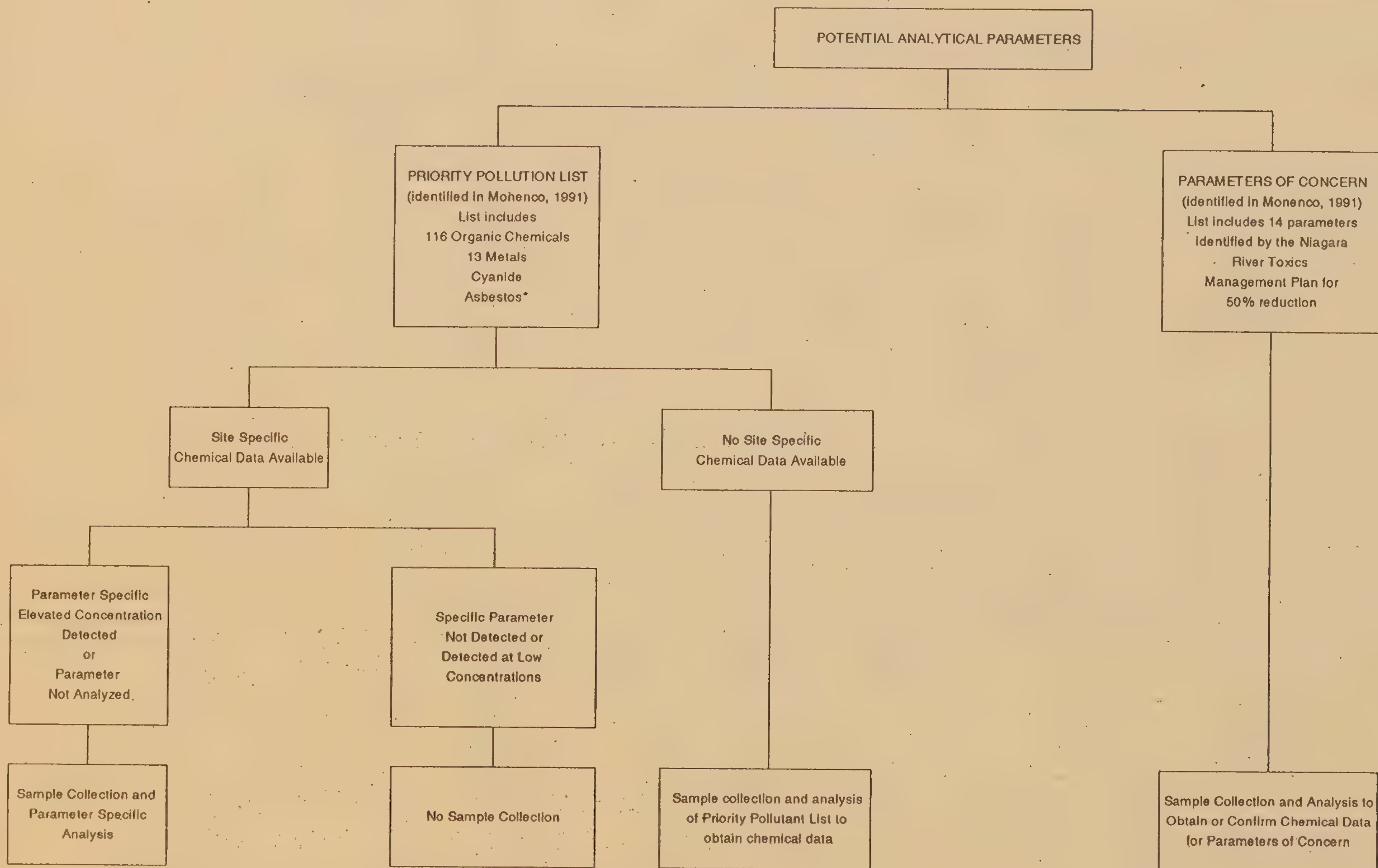
FIGURE 2-4
SITE PLAN
BRIDGE STREET MUNICIPAL LANDFILL SITE



* Asbestos omitted from analysis, nonmobile contaminant in ground water, not typically evaluated

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FIGURE 2-5
PROCESS USED TO SELECT ANALYTICAL PARAMETERS

February 12, 1993. The field program was completed at the following sites during the dates and for the activities noted below.

SITE	DATE	ACTIVITY
Cyanamid Canada Inc. Niagara Falls Landfill Sites	February 9, 1993 February 10, 1993	Well Purging Sample Collection
Cyanamid Canada Inc. Welland Landfill Site	February 5, 1993 February 8, 1993	Well Purging Sample Collection
Atlas Specialty Steels Landfill Site	February 3, 1993 February 4, 1993 February 12, 1993	Well Purging Sample Collection Sample Collection
Bridge Street Municipal Landfill Site	February 11, 1993	Well Purging Sample Collection

The procedures employed during the field program were as outlined in the document *Draft Sampling Plan For Ontario Based Landfills* (Jagger Hims Limited, 1992). A summary of field methods is provided in the following subsections for information purposes.

2.2.1 Water Level Measuring

Water levels at the monitoring wells were measured prior to purging using an electronic contact water level meter with stainless steel probe and graduated cable. The steel probe and graduated cable were cleaned/decontaminated prior to use and between monitoring stations. All water levels were referenced to the highest point on the well riser pipe. Water level measurements are listed in Table B1-1, Appendix B. Water level elevations in metres above sea level (m a.s.l.) are also included in Table B1-1.

2.2.2 Monitoring Well Purging

Prior to ground water sample collection, all monitoring wells were purged to remove standing water and accumulated sediment from the well casing and filter pack. Purging was accomplished using individually dedicated inertial lift pumps. The inertial lift pumps consisted of polyethylene tubing and a check valve.

Purging involved the removal of a minimum of one well volume and up to three standing water volumes from each monitoring well. The volumes removed were calculated from water level data on the day of purging as follows:

$$V_T = V_{case} + V_{sand}$$
$$V_T = [\pi(D\text{-}W)I^2 + n\,\pi\,L\,(O^2\text{-}I^2)] \times 1{,}000$$

where:

V_T	=	one well volume (litres)
V_{case}	=	volume in casing (litres)
V_{sand}	=	volume in sand pack (litres)
I	=	inside radius of casing (metres)
D	=	well depth (metres)
W	=	depth to water from top of riser (metres)
O	=	outside radius of boring (metres)
L	=	length of saturated sand (metres)
n	=	porosity of sand pack
π	=	constant (0.3)

Purging was monitored in the field for turbidity (visual), pH, temperature and conductivity. Details of monitoring well purging are summarized in Table B1-2, Appendix B.

2.2.3 Ground Water Sampling

Following purging, ground water samples were collected from monitoring wells once water levels had recovered sufficiently for sampling, typically within 24 hours of purging. For all sites, sampling for organic analyses was conducted using dedicated 6.4 millimetre (1/4 inch) polytubing inserted into the dedicated inertial lift pump. The polytubing was then removed from the inertial lift pump and the samples for general chemistry and inorganics analyses were collected. Samples collected for metals, cyanide and mercury analyses were field filtered using a 0.45 micron in-line filter. All samples were collected into precleaned laboratory sample bottles. Samples for metals and mercury analyses were preserved with nitric acid (HNO_3) to a pH of less than 2.5. Mercury samples were also preserved with 2.5 mL of potassium dichromate ($KCrO_7$). Samples for cyanide analysis were field preserved to a pH greater than 12 with sodium hydroxide (NaOH).

Samples were stored in ice packed coolers and submitted to the MOEE Central Laboratory in Rexdale within 24 hours of collection.

2.2.4 Surface Water Sample Collection

Surface water samples were collected using grab sample methods. Care was taken to minimize the disturbance of sediment during sampling. Where possible, samples were collected directly into precleaned laboratory bottles. However, at several stations (such as the Bridge Street Municipal Landfill Site and the Cyanamid Canada Inc. Niagara Falls Landfill Sites), low flow conditions prevented direct sampling. Thus samples were collected into a precleaned/decontaminated 250 mL glass beaker and decanted into the sample containers.

Surface water samples were not field filtered at the request of the MOEE. However, samples for inorganics and mercury were preserved to a pH less than 2.5 with HNO_3. The mercury sample was further preserved by adding 2.5 mL of $KCrO_7$. Samples for cyanide analysis were preserved with NaOH to a pH greater than 12.

Samples were stored in ice packed coolers and submitted to the MOEE Central Laboratory within 24 hours of collection.

3.0 LOADING CALCULATION

The potential contaminant loading (L) to the Niagara River for each site was calculated as:

$$L = [(C \times Q)\ \text{ground water} + (C \times Q)\ \text{surface water}] / A$$

where:

L	=	Potential Loading (kg/day)
C	=	Loading Concentration (mg/L)
Q	=	Water flux across downgradient site boundary (L/day)
A	=	Conversion Factor (1,000,000 mg/kg)

The calculation method, attributed to Gradient Corporation and GeoTrans, Inc. (1988), was used by Monenco (1991) to estimate contaminant loadings from Ontario based landfill sites based on historical analytical results.

Inherent in the above calculation are the following assumptions:

1) all contaminants present in samples were determined through analysis and accurately quantified;

2) no attenuation of contaminants occurs between the point of measurement (i.e. site boundary) and the Niagara River;

3) the water samples are representative of in situ conditions; and,

4) reasonable estimates of water flow rates are available or can be generated for each site.

Where possible, contaminant loadings were calculated for the major identified contaminant migration pathways including the overburden, the bedrock and surface water. Priority pollutant analytical data from the 1993 sampling event were used to calculate the loading concentrations for each pathway. In general, the loading concentration (C) for each flow path was estimated by summing the downgradient concentration for each analyte detected above the analysis detection limit. Where chemical data for two or more downgradient sampling stations along a contaminant migration pathway were available, the average or arithmetic mean concentration of each analyte was used to calculate loading concentrations for each pathway.

Priority pollutant parameters not detected in either the 1993 ground water or surface water samples were assumed not to be present at the sites and assigned a concentration of *zero* for purposes of the loading calculation. Specifically, the majority of the organic parameters analysed were below detection limits at all sites. Under circumstances where parameters were detected at one or more of the sampling stations at a site but were at concentrations below detection limit(s) at other sampling stations on-site, a concentration equal to the detection limit(s) was assigned. Where background chemical concentrations were available from the 1993 sampling event, downgradient contaminant concentrations were adjusted for background (upgradient) concentrations by subtracting the detected background concentration.

The contaminant concentrations for leachate, if the refuse was sampled, were conservatively assumed to be indicative of *worst case* contaminant concentrations. This approach assumes that the contaminant concentration would not be reduced between the sampling station within the refuse and the downgradient site boundary by natural attenuation processes.

Average (best) ground water flux (Q) values calculated by Monenco (1991) were used in the loadings calculation. Where appropriate, surface water flux rates were re-estimated as part of this study based on flow rates observed at the time of sampling. Flux rates for both ground water and surface water and the source of the data are listed in Table 3-1 on a site-by-site basis.

4.0 SITE SPECIFIC ANALYSIS OF CONTAMINANT LOADINGS TO THE NIAGARA RIVER

4.1 CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES

4.1.1 Loading Concentrations

Loading concentrations were estimated for five potential migration pathways from the Cyanamid Canada Inc. Niagara Falls Landfill Sites including: 1) bedrock ground water flow to the Queenston-Chippawa Power Canal; 2) overburden ground water flow to the Queenston-Chippawa Power Canal; 3) bedrock ground water flow to the Niagara River through the buried St. Davids Gorge; 4) overburden ground water flow to the Niagara River; and, 5) surface water flow to the Niagara River from a spring at the base of the Whirlpool Gorge. Concentrations for detected priority pollutant inorganics and organics are listed in Tables C1-1 and C1-2, for ground water and surface water, respectively. Background concentrations for bedrock and overburden are also included in Table C1-1, for comparison purposes. A summary of the observed concentrations follows.

Ten inorganic and eight organic priority pollutants were detected in ground water samples from the Cyanamid Canada Inc. Niagara Falls Landfill Sites. The parameters and pathways, where concentrations were detected above trace amounts, are summarized in Table 4-1.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER - ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: SUMMARY OF GROUND WATER AND SURFACE WATER FLUXES

TABLE NUMBER: 3-1

LOCATION	MIGRATION PATHWAY	ESTIMATED FLUX (L/day)	SOURCE	COMMENTS
Cyanamid Canada Inc. Niagara Falls Landfill Sites	Bedrock Ground Water To Queenston-Chippawa Power Canal	268,800	Monenco, 1991	Estimated using Darcy's Law, given the geometric mean hydraulic conductivity for 13 tests, and a downgradient site boundary length of 1200 metres.
	Overburden Ground Water To Queenston-Chippawa Power Canal	557,384	Monenco, 1991	Estimated using Darcy's Law, given the arithmetic mean hydraulic conductivity for 5 tests (on silty clay) and 23 tests (on silt and silty sand) and a downgradient site boundary length of 1200 metres.
	Bedrock Ground Water To Niagara River via buried St. Davids Gorge	67,200	Monenco, 1991	Estimated using Darcy's Law, given the geometric mean hydraulic conductivity for 13 tests, and a downgradient site boundary length of 300 metres.
	Overburden Ground Water To Niagara River	52,255	Monenco, 1991	Estimated using Darcy's Law, given the arithmetic mean hydraulic conductivity for 5 tests (on silty clay) and 23 tests (on silt and silty sand) and a downgradient site boundary length of 300 metres.
	Surface Water To Niagara River	10,800	1993 Field Observations	Field observations and a description of the measurement method are listed in Table B1-3.
Cyanamid Canada Inc. Welland Landfill Site	Bedrock Ground Water To Welland River	2,601	Monenco, 1991	Estimated using Darcy's Law, given the geometric mean hydraulic conductivity for 5 tests, and a downgradient site boundary length of 2200 metres.
	Overburden Ground Water To Welland River	55	Monenco, 1991	Estimated using Darcy's Law, given the geometric mean hydraulic conductivity for 17 tests on the upper fractured clay unit and a downgradient site boundary length of 2200 metres.
	Surface Water To Welland River via Thompson Creek	10,080,000	1993 Field Observations	Flow measurements were recorded by the Cyanamid Canada Inc. equipment at the time of sampling.
Atlas Specialty Steels Landfill Site	Overburden Ground Water To Welland River	1,067	Monenco, 1991	Estimated using a water budget given an infiltration rate of 0.76 cm/yr and an estimated rate of precipitation of 94 cm/yr, and a recharge area of 51260 square metres.
	Surface Water To Welland River		1993 Field Observations	Field observations and a description of the measurement method are listed in Table B1-4.
Bridge Street Municipal Landfill Site	Bedrock Ground Water To Welland River	4,665,600	Monenco, 1991	Estimated using Darcy's Law, given the mean hydraulic conductivity from 2 pumping tests and a downgradient site boundary length of 1500 metres.
	Overburden Ground Water To Welland River	5,702	Monenco, 1991	Estimated using Darcy's Law, given the arithmetic hydraulic conductivity from 9 tests and a downgradient site boundary length of 1500 metres.
	Surface Water To Welland River via Thompson Creek	<1440	1993 Field Observations	Low flow conditions were observed at the time of sample. Sampling station S4 was frozen. Station S4a, located 4 metres north of Bowen Road was partially ice free and was sampled.

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PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: PRIORITY POLLUTANT PARAMETERS DETECTED IN SAMPLES
CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES

TABLE NUMBER: 4-1

PARAMETER	CONCENTRATON (mg/L)					PROVINCIAL WATER QUALITY OBJECTIVES (1992)	ONTARIO DRINKING WATER OBJECTIVES (1992)
	BACKGROUND BEDROCK (BG1-I)	BACKGROUND OVERBURDEN (BG1-II)	DOWNGRADIENT BEDROCK (A1-8-I, C1-5-I)	DOWNGRADIENT OVERBURDEN (B1-10-II, C1-4-II)	DOWNSTREAM SURFACE WATER (SW16)		
INORGANICS							
Copper		0.0095	0.0004 - 0.0007	0.0120 - 0.0140	0.0059	0.005	1 AO
Nickel			0.001* - 0.005	0.010* - 0.052	0.025	0.025	
Lead	0.086	0.130	0.001 - 0.005	0.005* - 0.096	0.014	0.001 - 0.005	0.010 MAC
Zinc	0.6700	0.8900	0.013	0.2100 - 0.8300	0.0024	0.03	5 AO
Beryllium	0.00280	0.0014	0.00020 - 0.16000	0.00020 - 0.00420	0.00030	0.011 - 1.1 (6)	
Cyanide			0.340 - 15.000	1.200 - 8.800	1.200	0.005	0.2 MAC
Cadmium			0.0002* - 0.0006	0.0003 - 0.0020	0.0003	0.0002	0.005 MAC
Chromium	0.012	0.029	0.007 - 0.013	0.010* - 0.012	0.021	0.100	0.050 MAC
Mercury				0.02* - 0.04	0.03	0.0002	0.001 MAC
Antimony	0.003	0.004	0.002 - 0.015	0.002 - 0.009	0.010	0.007	
ORGANICS							
Phenol			0.0036 - 0.0630	0.0002* - 0.0600	0.1900	0.005 proposed	
Di-n-butylphthalate	0.0027	**	0.0** - 0.0005	0.0** - 0.0064	**		
Bis-2-ethylhexylphthalate	0.0020	0.0020	**	0.0** - 0.0020	**		
m-Cresol			0.0060 - 0.0011	0.0002 - 0.0334	0.0036	0.001 proposed	
p-Cresol			0.0044 - 0.0264		0.0115	0.001 proposed	
o-Cresol			0.0002* - 0.0012		0.0006	0.001 proposed	
Indole				0.0002* - 0.0140			
Hexachloroethane					0.000010	0.0005 proposed	
1,2,4 Trichlorobenzene			0.000002	0.000002		0.0005	

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Notes:

1) All concentrations are mg/L unless otherwise noted.
2) "Blank" indicates that parameter was not detected along pathway.
3) "*" indicates analytical detection limit
4) "**" indicates that the concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L is assumed.
5) "Shaded parameters are NRTC parameters of concern.
6) Objective is pH, alkalinity or hardness dependent; the actual objective is within the range cited.
7) "MAC" indicates maximum acceptable concentration.
8) "AO" incdicates aesthetic objective.

Copies of the Laboratory Analysis reports are included in Appendix D. The Provincial Water Quality Objectives (MOE, 1992b) and the Ontario Drinking Water Objectives (MOE, 1992c) are included in the table for information purposes. Downgradient detected priority pollutant inorganic concentrations ranged from 0.0002 mg/L for beryllium to 15 mg/L for cyanide. Detected organic concentrations ranged from 0.000002 mg/L for 1,2,4 trichlorobenzene to 0.063 mg/L for phenol.

The NRTC parameter of concern *lead* was detected in the downgradient ground water samples from the site in concentrations ranging from 0.005 mg/L to 0.096 mg/L. These concentrations are within the historical range of concentrations. Mercury, also an NRTC parameter of concern, was detected in one downgradient overburden ground water sample in a trace amount of 0.04 mg/L.

A number of the parameters detected at the downgradient site boundaries were also detected in samples collected from the background monitoring wells. Considering the proximity of the sampled background wells to the Cyanamid Canada Inc. Niagara Plant, it is conceivable that the detected parameters are present at elevated concentrations below the plant site and are therefore endemic to both the site and disposal areas. Because of the difficulties associated with distinguishing contaminant source through the limited sampling program, it was decided that the detected concentrations used in the loading calculation for this site would not be adjusted for background.

Parameters detected above analytical detection limits in the surface water sample are also summarized in Table 4-1. The NRTC parameters of concern, *lead* and *mercury*, were detected in the surface water sample. A total of ten priority pollutant inorganics and seven priority pollutant organics were detected in the surface water sample. Detected inorganic concentrations ranged from 0.0003 mg/L for cadmium and beryllium to 1.2 mg/L for cyanide. Detected organic concentrations ranged from 0.00001 mg/L for hexachloroethane to 0.190 mg/L for phenol. Similar parameters were detected in the ground water samples with the exception of hexachloroethane. Indole and 1,2,4 trichlorobenzene were detected in the downgradient ground water samples but not in the surface water sample.

To estimate the total concentrations for each migration pathway, individual parameter concentrations were summed. As noted above, loading concentrations were not adjusted

for background concentrations since the water quality at the background wells may not be representative of natural conditions. Estimated total concentrations are summarized in Table 4-2 on a migration pathway and type (inorganic or organic) basis. The total inorganic concentrations for the identified ground water contaminant migration pathways range from 0.5343 mg/L (for flow through bedrock to the Queenston-Chippawa Power Canal) to 15.0633 mg/L (for flow through bedrock to the Niagara River via the buried St. Davids Gorge). Cyanide contributed between about 55 percent (overburden ground water flow to the Niagara River) and 99.5 percent (bedrock ground water flow to the Niagara River via the buried St. Davids Gorge) of the total concentration.

Migration pathway total organic concentrations ranged between 0.0074 mg/L (for flow through overburden to the Niagara River) to 0.2057 mg/L (for surface water flow to the Niagara River). Phenol was the largest contributor to the organic concentration, accounting for up to 86 percent of the total organic concentration. Phenol concentrations detected in 1993 are slightly below historical concentrations reported in Gartner Lee Limited (1990). It should also be noted that phenol can be naturally occurring. Additional sampling would be required to distinguish between naturally occurring and landfill generated phenol concentrations.

4.1.2 Potential Loadings to the Niagara River

Loading estimates to the Niagara River for the Cyanamid Canada Inc. Niagara Falls Landfill Sites are summarized in Table 4-2. Detailed loading calculations are provided in Appendix C1. Loading estimates were prepared for the four identified ground water contaminant migration pathways and the surface water contaminant migration pathway.

Loading estimates ranged from 0.0164 kg/day (for the surface water migration pathway) to 5.1560 kg/day (for the overburden migration pathway to the Queenston-Chippawa Power Canal). Discounting background concentrations and other possible sources of loading, the total potential loading to the Niagara River from the Cyanamid Canada Inc. Niagara Falls Landfill Sites was estimated to be 6.4176 kg/day. Inorganic priority pollutant loadings accounted for about 99 percent of the total potential loading.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: POTENTIAL PRIORITY POLLUTANT LOADINGS TO THE NIAGARA RIVER CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES

TABLE NUMBER: 4–2

SOURCE	CONCENTRATION *(mg/L)*		FLUX *(L/day)*	LOADING *(kg/day)*
GROUND WATER				
Pathway 1: Bedrock via Queenston–Chippawa Power Canal	INORGANICS	0.3861	268800	0.1038
	ORGANICS	0.0369	268800	0.0099
	PATHWAY TOTAL			0.1137
Pathway 2: Overburden via Queenston–Chippawa Power Canal	INORGANICS	9.1405	557384	5.0948
	ORGANICS	0.1098	557384	0.0612
	PATHWAY TOTAL			5.1560
Pathway 3: Bedrock via Buried St. Davids Gorge	INORGANICS	15.0612	67200	1.0121
	ORGANICS	0.0699	67200	0.0047
	PATHWAY TOTAL			1.0168
Pathway 4: Overburden directly to Niagara River	INORGANICS	2.1882	52255	0.1143
	ORGANICS	0.0074	52255	0.0004
	PATHWAY TOTAL			0.1147
	GROUND WATER TOTAL			6.4012
SURFACE WATER				
Pathway 5: Spring Discharge to Niagara River	INORGANICS	1.3089	10800	0.0141
	ORGANICS	0.2057	10800	0.0022
	SURFACE WATER TOTAL			0.0164
TOTAL LOADING (GROUND WATER PATHWAYS + SURFACE WATER PATHWAY)				6.4176

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Note:

1) Total loadings are presented to reflect the lowest concentration detected.

Loadings for the Cyanamid Canada Inc. Niagara Falls Landfill Sites based on historical chemical analyses ranged from 1.8 kg/day to 259.0 kg/day with an average (*best*) estimate of 26.9 kg/day (Monenco, 1991). The 1993 loading estimate, intended to represent average site conditions, was within the loading estimate range calculated from the historical data base, but was more than five times lower than Monenco's *best* estimate. The discrepancy between the 1993 loading estimate and Monenco's estimate is attributable to the statistics used to calculate the loadings estimate from the historical chemical data base. The concentration ranges used by Monenco (1991) to estimate loadings included cyanide only and are summarized in Table 4-3 on a pathway basis. For comparison purposes, cyanide concentrations detected in the samples collected as part of this study are also listed in the table. The averages used in Monenco's 1991 loading estimate were several orders of magnitude greater than the concentrations detected in 1993 for bedrock ground water flow to the Queenston-Chippawa Power Canal and overburden ground water flow to the Niagara River. However Monenco's values are generally skewed by an elevated concentration observed for a single monitoring well.

The certainty of the loading estimates to the Niagara River from the Cyanamid Canada Inc. Niagara Falls Landfill Sites is moderate. Concentrations detected within samples collected in 1993 were within historical ranges for samples collected from the monitoring wells. Most of the parameters used in the loading calculations were detected in all monitoring wells.

The loading estimates for this study assume that no natural attenuation of parameters occurs between the sampling stations and the Niagara River to be consistent with previous investigators (Gradient Corporation and GeoTrans, Inc., 1988; Monenco, 1991). Cyanide, which is the largest single contributor to the loading concentrations from this site can be attenuated in the subsurface through biodegradation, adsorption, precipitation or oxidation. Thus, the calculated potential loading to the Niagara River from the Cyanamid Canada Inc. Niagara Falls Landfill Sites is likely to be conservatively high.

In the long term, the calculated potential loading to the Niagara River is also likely to be conservatively high. Remedial works are reportedly proposed for the Cyanamid Niagara Falls Landfill Sites. Additional sampling and analysis, following the implementation of remedial systems will be required to evaluate the post-closure (long term) contaminant loadings to the Niagara River from the site.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: SUMMARY OF CONCENTRATIONS USED IN HISTORICAL LOADING ESTIMATES CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES

TABLE NUMBER: 4-3

MIGRATION PATHWAY	HISTORICAL CYANIDE CONCENTRATION (1) *(mg/L)*			1993 CYANIDE CONCENTRATION *(mg/L)*
	RANGE	AVERAGE	NOTES	
Bedrock ground water flow to Queenston-Chippawa Power Canal	0.07 – 58.00	13.55	Calculation considered chemistry for two sampling events from seven bedrock wells. Concentrations detected included: 3 concentrations ranged from 0.07 to 1.0 mg/L 2 concentrations ranged from 1.0 to 10.0 mg/L 1 concentration ranged from 10.0 to 30.0 mg/L 1 concentration of 58.0 mg/L	0.340
Overburden ground water flow to Queenston-Chippawa Power Canal	0.03 – 186.30	13.55	Calculation considered chemistry for two sampling events from seven overburden wells. Concentrations detected included: 5 concentrations ranged from 0.03 to 1.0 mg/L 1 concentration ranged from 1.0 to 30.0 mg/L 1 concentration of 186.30 mg/L	8.80
Bedrock ground water flow to through buried St. Davids Gorge	0.07 – 73.50	24.86	Calculation considered chemistry for two sampling events from four bedrock wells. Concentrations detected included: 2 concentrations ranged from 0.07 to 1.0 mg/L 1 concentration ranged from 1.0 to 30.0 mg/L 1 concentration of 73.5 mg/L	15.000
Overburden ground water flow to Niagara River	0.02 – 301.50	75.56	Calculation considered chemistry for two sampling events from four overburden wells. Concentrations detected included: 3 concentrations ranged from 0.02 to 1.0 mg/L 1 concentration of 301.5 mg/L	1.200

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Notes:

1) From data presented in Monenco (1991).

Loadings from potential contaminant migration pathways which were not investigated in this study included: 1) overburden ground water flow to the Niagara River through the buried St. Davids Gorge; 2) bedrock ground water flow directly to the Niagara River; and 3) surface water flow to the Queenston-Chippawa Power Canal. The estimated loadings calculated by Monenco (1991) for these potential pathways are 0.0 kg/day, 0.1 kg/day, and 0.7 kg/day, respectively. Additional sampling and analysis would be required to confirm these estimates.

Other potential sources of contaminants to the Niagara River in the vicinity of the Cyanamid Canada Inc. Niagara Falls Landfill Sites that may influence the total potential loadings estimated in this study include the CN Rail Lands Victoria Avenue Landfill Site and the Victoria Avenue Municipal Landfill Site. The approximate locations of these two sites are shown in the Cyanamid Canada Inc. Niagara Falls Site Plan (Figure 2-1). Recent chemical data are not available for these sites.

4.2 CYANAMID CANADA INC. WELLAND LANDFILL SITE

4.2.1 Loading Concentration

Average ground water loading concentrations for priority pollutants at the downgradient site boundary of the Cyanamid Canada Inc. Welland Landfill Site were estimated for overburden and bedrock migration pathways based on single samples collected from each of monitoring wells 5-IV and 5-I, respectively. *Worst case* ground water concentrations were estimated for the site using the analytical data for the sample collected from monitoring well 23-I which is completed in waste. Additionally, surface water loading concentrations were estimated for Thompson Creek, a tributary of the Welland River which bisects the site. Surface water samples collected upstream and downstream of the landfill site were analysed. A listing of detected parameter concentrations is presented in Tables C2-1 and C2-2, Appendix C2, for ground water and surface water, respectively.

Priority pollutant parameters detected in ground water samples from the Cyanamid Canada Inc. Welland Landfill Site include the seven inorganics and fourteen organic parameters listed in Table 4-4. The Provincial Water Quality Objectives (MOE, 1992b) and the Ontario Drinking Water Objectives (MOE, 1992c) are included in the table for information

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: PRIORITY POLLUTANT PARAMETERS DETECTED IN SAMPLES
CYANAMID CANADA INC. WELLAND LANDFILL SITE

TABLE NUMBER: 4-4

PARAMETER	CONCENTRATION (mg/L)				PROVINCIAL WATER QUALITY OBJECTIVES (1992)		ONTARIO DRINKING WATER OBJECTIVES (1992)	
	DOWNGRADIENT BEDROCK GROUND WATER (5-I)	DOWNGRADIENT OVERBURDEN GROUND WATER (5-IV)	WASTE (23-I)	SURFACE WATER (C1, C9)				
INORGANICS								
Copper	0.0240	0.0170	0.0040	0.0028 - 0.0042	0.005		1.0	AO
Lead	0.084	0.052	0.120	0.010 - 0.013 *	0.001 - 0.005	(7)	0.01	MAC
Zinc	1.7000	1.1000	2.1000	0.0020 - 0.0036	0.03		5.0	AO
Silver				0.0005 - 0.0024 *	0.0001			
Beryllium	0.00280	0.0008	0.00280	0.00010 - 0.00040	0.011 - 1.1	(7)		
Cyanide			215.470	0.014 - 0.022	0.005		0.2	MAC
Chromium	0.016	0.022	0.021	0.003	0.1		0.05	MAC
Antimony	0.002	0.004	0.011		0.007	proposed		
ORGANICS								
Phenol			0.0690		0.005	proposed		
Di-n-butylphthalate	**	0.0022	0.0290	0.0051 - 0.0054				
Bis-2-ethylhexylphthalate	**	**	0.0210	0.0** - 0.0010				
Chloroform	**	**	0.0180	0.0** - 0.002				
Toluene		0.0004		0.0004*** - 0.0020	0.0008	proposed	0.024	AO
m-Cresol			0.0032		0.001	proposed		
Indole			0.0150					
Hexachloroethane		0.000003			0.0005	proposed		
1,2,4 Trichlorobenzene	0.000007	0.000003			0.0005			
Hexachlorobutadiene		0.000006			0.00007	proposed		
1,2,3 Trichlorobenzene		0.000001			0.0009			
2,3,6 Trichlorotoluene		0.000003						
1,2,3,5 Tetrachlorobenzene		0.000015			0.0001			
Hexachlorobenzene		0.000005			0.0000065			
Heptachlor		0.000010			0.000001		0.28	IMAC
Chlorobenzene				0.0002*** - 0.0200	0.015			
Pentachlorobenzene		0.000009			0.00003			

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Notes:

1) All concentrations are mg/L unless otherwise noted.
2) "Blank" indicates that parameter not detected along migration pathway.
3) "**" indicates that the parameter was detected at higher concentrations upstream of the site than downstream of the site.
4) "***" indicates that the concentration detected in the laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L is assumed.
5) "****" indicates analytical detection limit.
6) Shaded parameters are NRTC parameters of concern.
7) Objective is pH, alkalinity or hardness dependent; the actual objective is within the range cited.
8) "MAC" indicates maximum acceptable concentration.
9) "IMAC" indicates interim maximum acceptable concentration.
10) "AO" indicates aesthetic objective.

purposes. Parameter concentrations were generally detected at higher concentrations for the leachate sample as compared with the ground water samples. Generally organic parameters, with the exception of phenol, were only detected above trace levels in samples collected from the single downgradient overburden monitoring well.

The NRTC parameter of concern *lead* was detected at concentrations ranging from 0.052 mg/L (downgradient overburden ground water) to 0.120 mg/L (waste water sample). Hexachlorobenzene, also a NRTC parameter of concern, was detected at a trace concentration of 0.000005 mg/L in the ground water sample collected from the downgradient overburden well. The source of the hexachlorobenzene is not known. It was not detected in the samples for wells completed in the waste or the bedrock. A field blank was not submitted for analysis and it is not known whether the parameter is a sampling artifact. Additional sampling and analysis would be required to confirm the occurrence of this parameter in overburden ground water.

Seven inorganic parameters and five organic parameters were detected in surface water from Thompson Creek downstream of the site (see Table 4-4). With the exception of lead, chromium and silver, parameters detected upstream of the site were detected at increased concentrations downstream. Downstream inorganic parameter concentrations ranged from 0.0004 mg/L (for beryllium) to 0.0220 mg/L (for cyanide). Organic concentrations ranged from 0.002 mg/L (for chloroform) to 0.0200 mg/L (for chlorobenzene). All parameters detected in surface water, with the exception of silver, chlorobenzene and toluene, were also detected in the leachate sample from monitoring well 23-I.

An estimate of the total concentration for each migration pathway (overburden, bedrock and surface water) is provided in Table 4-5. The estimates were calculated by summing the parameter concentrations for each pathway. Parameter concentrations for surface water samples collected downstream of the waste area were adjusted for background by subtracting concentrations detected in the surface water sample collected upstream of the site. For lead, chromium, and silver, which were detected at higher concentrations upstream of the site, the site contribution for the purposes of the loading calculation was assumed to be zero.

4.2.2 Potential Loadings to the Welland River

Loading estimates for the Cyanamid Canada Inc. Welland Landfill Site are summarized in Table 4-5. A sample calculation is included in Appendix C2. Potential contaminant loadings to the Welland River via the ground water pathway range from 0.0001 kg/day for overburden to 0.0048 kg/day for bedrock. Potential loadings to the Welland River from Thompson Creek were estimated to be about 0.36 kg/day. Discounting background ground water concentrations and other possible contaminant sources, the total potential loading to the Welland River from the Cyanamid Canada Inc. Welland Landfill Site was estimated to be 0.3677 kg/day.

Loading estimates for the Cyanamid Canada Inc. Welland Landfill Site based on historical chemical analyses ranged from 0.001 kg/day to 0.03 kg/day (Monenco, 1991), which is considerably less than the values calculated based on the 1993 analysis results. The elevated 1993 loading estimate can be accounted for in three ways. Firstly, the historical chemical data base did not include organic parameter concentrations as they were not considered a concern at the site. Organic parameters accounted for about 65 percent of the total loadings for the site in 1993.

Secondly, historical loading estimates considered only cyanide and fluoride concentrations in the calculation of total loading concentration. To provide a conservative estimate of the total loading concentration in this study, all priority pollutant parameters detected on-site were included in the loading calculation. Fluoride, not a priority pollutant, was not analysed in the 1993 program. Cyanide accounts for approximately two percent of the total inorganic parameter concentration used in the loading calculation. Thus, the omission of other priority pollutant inorganics in previous estimates could underestimate the total loading to the Welland River.

Thirdly, surface water loadings to the Niagara River from Thompson Creek were included in the 1993 loading estimate. The historical loading estimates for Thompson Creek did not include the surface water loadings, but instead were based on analytical results for ground water samples collected from creek bed mini-piezometers. Thus the historical estimate appears to have excluded the surface water runoff contribution from the landfill site. It should, however, be noted that the inclusion of surface water loadings likely overestimates

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TABLE NAME: POTENTIAL PRIORITY POLLUTANT LOADINGS TO THE WELLAND RIVER CYANAMID CANADA INC. WELLAND LANDFILL SITE

TABLE NUMBER: 4-5

SOURCE	CONCENTRATION (mg/L)		FLUX (L/day)	LOADING (kg/day)
GROUND WATER				
Bedrock	INORGANICS	1.8298	2601	0.0048
	ORGANICS	0.0026	2601	0.0000
	BEDROCK PATHWAY TOTAL			0.0048
Overburden	INORGANICS	1.1968	55	0.0001
	ORGANICS	0.0033	55	0.0000
	OVERBURDEN PATHWAY TOTAL			0.0001
	GROUND WATER PATHWAY TOTAL			0.0048
SURFACE WATER				
	INORGANICS	0.0113	10080000	0.1139
	ORGANICS	0.0247	10080000	0.2490
	SURFACE WATER PATHWAY TOTAL			0.3629
TOTAL LOADINGS (SURFACE WATER PATHWAY + GROUND WATER PATHWAY)				0.3677

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Notes:

1) Total loadings are presented to reflect the lowest concentrations detected.

the influence of the landfill site on Thompson Creek because effluent from the Cyanamid Canada Inc. Welland Plant is reportedly discharged into the creek between the upstream and downstream sampling stations. Storm water runoff from the Cyanamid Canada Inc. Welland Plant Site may also be contributing to the loadings to the creek. Additional sampling and analysis would be required to determine the affect of effluent discharge on the contaminant loading calculation. Sampling and re-evaluation of loadings following the completion of remedial works underway at the plant site are also required to determine the effect of storm water runoff on the loading concentration.

The estimate of *worst case* loading to the Welland River from the Cyanamid Canada Inc. Welland Landfill Site is based on parameter concentrations for the sample collected from the well completed in the waste and the average ground water flux rate for both overburden and bedrock. The estimated value is presented in Table 4-6 and a sample calculation is provided in Appendix C2. Based on the *worst case* scenario, the potential loadings to the Welland River from the Cyanamid Canada Inc. Welland Landfill Site is 0.9570 kg/day. The *worst case* scenario unrealistically assumes no attenuation of contaminants occurs during migration through the overburden and bedrock to the downgradient site boundary.

4.3 ATLAS SPECIALTY STEELS LANDFILL SITE

4.3.1 Loading Concentrations

Loading concentrations at the downgradient site boundary of the Atlas Specialty Steels Landfill Site were estimated for the overburden and surface water migration pathways based on the analytic results for three overburden ground water samples and one surface water sample. The concentrations of detected parameters are listed in Tables C3-1 and C3-2 for ground water and surface water samples, respectively. A summary of the chemical data is presented in the following paragraphs.

Priority pollutant parameters detected in ground water samples from the Atlas Specialty Steels Landfill Site are summarized in Table 4-7. For information purposes, the Provincial Water Quality and Drinking Water Objectives (MOE, 1992b and 1992c, respectively) are included in the table. Downgradient inorganic concentrations ranged from 0.0002 mg/L for

PROJECT NAME: CONTAINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: WORST CASE PRIORITY POLLUTANT LOADINGS TO THE WELLAND RIVER CYANAMID CANADA INC. WELLAND LANDFILL SITE

TABLE NUMBER: 4-6

SOURCE	CONCENTRATION (mg/L)		FLUX (L/day)	LOADING (kg/day)
LEACHATE				
Bedrock	INORGANICS	217.7288	2601	0.5663
	ORGANICS	0.1752	2601	0.0005
	BEDROCK PATHWAY TOTAL			0.5668
Overburden	INORGANICS	217.7288	55	0.0120
	ORGANICS	0.1752	55	0.0000
	OVERBURDEN PATHWAY TOTAL			0.0120
	GROUND WATER PATHWAY TOTAL			0.5788
SURFACE WATER				
	INORGANICS	0.0113	10080000	0.1139
	ORGANICS	0.0247	10080000	0.2490
	SURFACE WATER PATHWAY TOTAL			0.3629
TOTAL LOADINGS (WORST CASE)				0.9416

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Notes:

1) Total loadings are presented to reflect the lowest concentrations detected.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: PRIORITY POLLUTANTS DETECTED IN SAMPLES
ATLAS SPECIALITY STEELS LANDFILL SITE

TABLE NUMBER: 4-7

PARAMETER	CONCENTRATION (mg/L)		PROVINCIAL WATER QUALITY OBJECTIVES (1992)		ONTARIO DRINKING WATER OBJECTIVES (1992)	
	DOWNGRADIENT OVERBURDEN GROUND WATER (AS 12, AS 13, AS 14)	SURFACE WATER (SS 3)				
INORGANICS						
Copper	0.0058 - 0.0260	0.0210 - 0.0220	0.005		1.0	AO
Nickel	0.008 - 1.400	0.029	0.025			
Lead	0.032 - 0.062	0.020 - 0.033	0.001 - 0.005	(6)	0.01	MAC
Zinc	0.0005* - 0.6800				5.0	AO
Silver	0.0005* - 0.0025					
Beryllium	0.00020 - 0.00280	0.00030	0.011-1.1	(6)		
Cyanide		0.054 - 0.150	0.005		0.2	MAC
Cadmium	0.0002* - 0.0007		0.0002		0.005	MAC
Chromium	0.001* - 0.013	0.290 - 0.310	0.1		0.05	MAC
Mercury		0.02 - 0.03	0.0002		0.001	MAC
Antimony	0.003 - 0.006	0.002 - 0.003	0.007	proposed		
ORGANICS						
Phenol	0.0002* - 0.0326	0.0131 - 0.0144	0.005	proposed		
Bis-2-ethylhexylphthalate	0.0** - 0.0010	0.0* - 0.0140				
Di-n-butylphthalate	0.0** - 0.0017	0.0*				
1,1 Dichloroethylene		0.0010 - 0.0020	0.040	proposed		
Chloroform	0.0** - 0.0020	0.0004				
Trichloroethylene	0.001* - 0.0150	0.0500 - 0.0540	0.002	proposed	0.05	MAC
Toluene	0.0002* - 0.0006	0.0010	0.0008	proposed	0.024	AO
Tetrachloroethylene		0.0005	0.050	proposed		
m-Cresol	0.0002 - 0.0011	0.0013 - 0.0015	0.001	proposed		
Indole	0.0002 - 0.0068	0.0002 - 0.0008				
p-Cresol	0.0002 - 0.0008	0.0008 - 0.0009	0.001	proposed		
1-Methylnapthalene		0.0006 - 0.0007	0.002	proposed		
2-Methylnapthalene		0.0006 - 0.0007	0.002	proposed		
Hexachloroethane		0.000002	0.0005	proposed		
1,3,5 Trichlorobenzene		0.000005 - 0.000006	0.00065			
1,2,4 Trichlorobenezene	0.000002* - 0.000003	0.000034 - 0.000040	0.0005			
1,2,3 Trichlorobenezene		0.000023 - 0.000030	0.0009			
1,2,3,5 Tetrachlorobenezene		0.000003 - 0.000004	0.0001			
1,2,4,5 Tetrachlorobenezene		0.000004 - 0.000009	0.00015			
1,2,3,4 Tetrachlorobenezene		0.000015 - 0.000018	0.0001			
Pentachlorobenezene	0.000001 - 0.000002	0.000001 - 0.000002	0.00003			
Hexachlorobenezene	0.000001* - 0.000007	0.000001	0.0000065			
Endosulfan I	0.000002* - 0.000006		0.000003			

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Notes:

1) All concentrations are mg/L unless otherwise noted.
2) "Blank" indicates that the parameter was not detected along the pathway.
3) "*" indicates analytical detection limit.
4) "**" indicates that the concentration detected in the laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L was assumed.
5) Shaded parameters are NRTC parameters of concern.
6) Objective is pH, alkalinity, or hardness dependent; the actual objective is within the range cited.
7) "MAC" indicates maximum acceptable concentration.
8) "AO" indicates aesthetic objective.

beryllium to 1.4 mg/L for nickel. Organic parameters detected ranged in concentration from 0.000001 mg/L for pentachlorobenzene to 0.0326 mg/L for phenol.

The NRTC parameter of concern *lead* was detected in the overburden ground water samples at concentrations up to 0.062 mg/L. It should be noted that lead is known to occur naturally in ground water in concentrations up to about 0.04 mg/L (Environment Canada, 1979). No historical data for lead concentrations in site ground water are presented in the reports on the site made available to Jagger Hims Limited by the MOEE. Further sampling and analysis of site ground water would be required to confirm the presence and concentrations detected. Sampling and analysis of upgradient (background) ground water would be required to distinguish between naturally occurring and landfill derived lead concentrations.

Hexachlorobenzene, also an NRTC parameter of concern, was detected in a trace concentration of 0.000007 mg/L in the overburden ground water sample collected from monitoring well AS 13. Additional sampling and analysis would be required to confirm its occurrence in overburden ground water.

Eight priority pollutant inorganic parameters were detected in the surface water sample from the Atlas Specialty Steels Landfill Site (Table 4-7) including the NRTC parameters of concern *mercury* and *lead*. Lead was detected in the surface water sample in concentrations up to 0.033 mg/L. Mercury, which was not detected in ground water samples collected from the site, was detected at a trace concentration of 0.03 mg/L in a sequential surface water sample collected at the weir for quality control purposes.

Twenty-one organic priority pollutants including the NRTC parameters of concern *hexachlorobenzene* and *tetrachloroethylene* were detected in surface water samples collected on-site. Detected concentrations ranged from 0.000001 mg/L for pentachlorobenzene and hexachlorobenzene to 0.054 mg/L for trichloroethylene. Organic concentrations were within the historical ranges reported for surface water samples (Monenco, 1991).

Total concentrations calculated for the site are summarized in Table 4-8 on a migration pathway and parameter type (inorganic and organic) basis. The sum of the arithmetic mean concentration of each analyte detected in ground water was used to estimate the total

concentration for the overburden migration pathway. The analytical results for three downgradient monitoring wells were included in the average analyte concentration calculation. Concentrations were estimated for the surface water migration pathway by summing the average (arithmetic mean) analyte concentration detected in the surface water sample and a duplicate sample. Total inorganic concentrations ranged between 0.7685 mg/L of ground water and 0.5068 mg/L for surface water. Nickel accounted for about 62 percent of the total inorganic parameter concentration in ground water, while chromium accounted for about 59 percent of the inorganic parameter concentrations in surface water.

Total organic parameter concentrations ranged between 0.0223 mg/L for ground water to 0.0803 mg/L for surface water. Up to about 73 percent of the total organic concentrations in both ground water and surface water is attributable to phenol. However, as phenol can be either naturally occurring or due to contamination from the site, additional sampling and analysis, including a background well would be required to confirm the occurrence of phenol.

4.3.2 Potential Loadings to the Welland River

Loading estimates for ground water and surface water contaminant migration pathways to the Welland River from the Atlas Specialty Steels Landfill Site are summarized in Table 4-8. A sample loading calculation is included in Appendix C3. Potential loadings range from 0.0008 kg/day for ground water flow through overburden to 0.0534 kg/day for the surface water pathway. Discounting background parameter concentrations and other potential contaminant sources, the total potential loading to the Welland River was estimated as 0.0534 kg/day. Inorganic priority pollutant loadings accounted for about 86 percent of the total potential loadings.

Potential loadings to the Welland River estimated from the historical chemical data base ranged from 0.5 kg/day to 1 kg/day (Monenco, 1991), which are greater than those estimated for the 1993 sampling program. The discrepancy between the loading estimates is attributed to the use of non-priority pollutants, such as aluminum, barium, iron, manganese, magnesium, molybdenum, and strontium, in the historical estimation of loadings to the Welland River. For comparison with the historic results, a second loading estimate that included all inorganic parameters detected in 1993 was calculated for the site. The loading

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: POTENTIAL PRIORITY POLLUTANT LOADINGS TO THE WELLAND RIVER ATLAS SPECIALITY STEELS LANDFILL SITE

TABLE NUMBER: 4-8

SOURCE		CONCENTRATION *(mg/L)*	FLUX *(L/day)*	LOADING *(kg/day)*
GROUND WATER				
	INORGANICS	0.7685	1067	0.0008
	ORGANICS	0.0223	1067	0.0000
	GROUND WATER PATHWAY TOTAL			0.0008
SURFACE WATER				
	INORGANICS	0.5068	91022	0.0461
	ORGANICS	0.0803	91022	0.0073
	SURFACE WATER TOTAL			0.0534
TOTAL LOADINGS				0.0543

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Notes:

1) Total loadings are presented to reflect the lowest concentration detected.

concentrations and potential loading estimate are summarized in Table 4-9. Sample calculations are included in Appendix C3. The loading estimate calculated using all inorganic analytes is about 0.65 kg/day which is comparable to the historic estimates.

The certainty of the loading estimates for the Atlas Specialty Steels Landfill Site is moderate. The majority of the parameters used to calculate the loading concentrations were detected above the analytical detection limits at all sampling stations, thus removing the need to approximate parameter concentrations. Although ground water loadings were not adjusted for background concentrations, the ground water component of the total loading estimate was minor (1 percent) relative to the surface water loading (99 percent). It should be noted, however, that the surface water flux rate used to calculate loading is conservatively high. Flow through the weir structure is controlled such that flow is allowed only at infrequent intervals, not daily as assumed in the calculation presented herein.

Possible additional loading pathways to the Welland River from the Atlas Specialty Steels Landfill Site include the deeper overburden and the bedrock. The monitoring wells sampled for this study are screened at the base of the berm at the downgradient site boundary and do not account for potentially contaminated ground water flow below the berm. Although deeper overburden monitoring wells were completed on-site, they were in poor repair and were not suitable for collection of representative ground water samples. No bedrock monitoring wells were installed on-site.

4.4 BRIDGE STREET MUNICIPAL LANDFILL SITE

4.4.1 Loading Concentrations

Total loading concentrations were estimated for three potential migration pathways from the Bridge Street Municipal Landfill Site including: 1) bedrock ground water flow to the Niagara River; 2) overburden ground water flow to the Niagara River; and 3) surface water flow to the Niagara River from Miller Creek. In order to estimate *worst case* parameter concentrations for the migration pathways, samples were also collected from one monitoring well (OW17-6) screened immediately below the refuse. Concentrations for detected inorganic priority pollutant parameters are listed in Tables C4-1 and C4-2, Appendix C4, for ground water and surface water, respectively.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: POTENTIAL NON PRIORITY POLLUTANT LOADINGS TO THE WELLAND RIVER ATLAS SPECIALITY STEELS LANDFILL SITE

TABLE NUMBER: 4-9

SOURCE		CONCENTRATION (mg/L)	FLUX (L/day)	LOADING (kg/day)
GROUND WATER				
	INORGANICS	21.8315	1067	0.0233
	ORGANICS	0.0308	1067	0.0000
	GROUND WATER PATHWAY TOTAL			0.0233
SURFACE WATER				
	INORGANICS	6.8056	91022	0.6195
	ORGANICS	0.0000	91022	0.0000
	SURFACE WATER TOTAL			0.6195
TOTAL LOADINGS				0.6428

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Notes:

1) Total loadings are presented to reflect the lowest concentration detected.

Seven inorganic parameters were detected in downgradient ground water samples from the Bridge Street Municipal Landfill Site. The parameters are listed in Table 4-10. Provincial Water Quality Objectives (MOE, 1992a) and the Ontario Drinking Water Objectives (MOE, 1992b) have been included for information purposes. Detected inorganic concentrations ranged from 0.0014 mg/L for beryllium in the downgradient bedrock ground water sample to 0.7800 mg/L for zinc in the downgradient overburden ground water sample. The sample collected from OW17-6, screened below the refuse generally had lower inorganic parameter concentrations than the ground water samples.

Organic parameters detected above trace concentrations in downgradient ground water samples are also listed in Table 4-10. Detectable concentrations range from 0.000001 mg/L (for hexachloroethane in the bedrock ground water sample) to 0.005 mg/L (for bis-(2-ethylhexyl)phthalate in the overburden ground water sample).

The NRTC parameters of concern *lead, hexachlorobenzene* and *chlordane* were detected in several samples from the site. *Lead* was detected in the downgradient bedrock ground water sample at a concentration of 0.24 mg/L and the sample collected from below the refuse at a concentration of 0.12 mg/L. *Hexachlorobenzene* and *chlordane* were detected at trace concentrations in the sample collected from the well screened below the waste.

Table 4-10 also lists the parameters which were detected above analytical detection limits in the single surface water sample from Miller Creek. No NRTC parameters of concern were detected in the surface water sample. The detected range of concentrations are similar to those observed for the ground water samples.

Only two organic parameters (di-n-butyl phthalate and bis-(2-ethylhexyl)phthalate) were detected in the surface water sample. These parameters were detected in all samples collected on-site, as well as in the laboratory blank. They are common sampling and laboratory artifacts. Additional sampling and analysis would be required to confirm their occurrence and concentration.

Total concentrations for priority pollutant parameters are summarized in Table 4-11 on a migration pathway and parameter group (inorganic and organic) basis. Total inorganic loading concentration ranged from 0.6284 mg/L for surface water to 1.0314 mg/L for

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: PRIORITY POLLUTANT PARAMETERS DETECTED IN SAMPLES
BRIDGE STREET MUNICIPAL LANDFILL SITE
TABLE NUMBER: 4-10

PARAMETER	CONCENTRATION (mg/L)				PROVINCIAL WATER QUALITY OBJECTIVES (1992)	ONTARIO DRINKING WATER OBJECTIVES (1992)
	DOWNGRADIENT BEDROCK GROUND WATER (OW29-14)	DOWNGRADIENT OVERBURDEN GROUND WATER (OW23-5)	BELOW WASTE (OW17-6)	DOWNSTREAM SURFACE WATER (S4a)		
INORGANICS						
Copper	0.0140	0.0047	0.0120		0.005	1.0 AO
Nickel	0.017			0.010	0.025	
Lead	0.240		0.120		0.001 - 0.005 (4)	0.01 MAC
Zinc	0.7200	0.7800	0.7300	0.670	0.03	5.0 AO
Beryllium	0.00140	0.00280	0.00280	0.00140	0.011 - 1.1 (4)	
Chromium	0.021	0.012	0.016	0.017	0.01	0.05 MAC
Antimony	0.008	0.012	0.010	0.001	0.007 proposed	
ORGANICS						
Di-n-butylphthalate	0.0023	*	0.0026	0.0052		
Bis-2-ethylhexylphthalate	0.0040	0.0050	0.0040	0.002		
Dichloromethane			0.0500			0.05 MAC
1,1 Dichloroethane			0.0150		0.2 proposed	
Chloroform		0.0002				
Benzene			0.0010		0.1 proposed	0.005 MAC
Trichloroethylene		0.0010			0.002 proposed	0.05 MAC
Toluene	0.0004	0.0006	0.0006		0.0008 proposed	0.024 AO
Chloroethane			0.0070			
Chloromethane			0.0020			
Hexachloroethane	0.000001	0.000005			0.0005 proposed	
1,2,4 Trichlorobenzene			0.000003		0.0005	
Pentachlorobenzene	0.000004		0.000001		0.00003	
Hexachlorobenzene			0.000007		0.0000065	
G-Chlorodane			0.000016		0.00006	0.007 MAC

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Notes:

1) All concentrations are mg/L unless otherwise noted.
2) "Blank" indicates parameter was not detected along migration pathway.
3) "*" indicates that the concentration detected in the laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L is assumed.
4) Shaded parameters are NRTC parameters of concern.
5) Objective is pH, alkalinity or hardness dependent; the actual objective is within the range cited.
6) "MAC" indicates maximum acceptable concentration.
7) "AO" indicates aesthetic objective.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039.00
TABLE NAME:	POTENTIAL PRIORITY POLLUTANT LOADINGS TO THE NIAGARA RIVER BRIDGE STREET MUNICIPAL LANDFILL SITE
TABLE NUMBER:	4–11

SOURCE	CONCENTRATION	*(mg/L)*	FLUX *(L/day)*	LOADING *(kg/day)*
GROUND WATER				
Bedrock	INORGANICS	1.0204	4665600	4.7608
	ORGANICS	0.0111	4665600	0.0518
	PATHWAY TOTAL			4.8126
Overburden	INORGANICS	0.8715	5702	0.0050
	ORGANICS	0.0100	5702	0.0001
	PATHWAY TOTAL			0.0050
	GROUND WATER PATHWAY TOTAL			4.8176
SURFACE WATER				
	INORGANICS	0.6284	1440	0.0009
	ORGANICS	0.0072	1440	0.0000
	SURFACE WATER TOTAL			0.0009
TOTAL LOADINGS				4.8186

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Notes:

1) Total loadings are presented to reflect the lowest concentration detected.

bedrock ground water. Zinc accounted for up to 97 percent of the total inorganic concentration in ground water and surface water samples. For information purposes, the total concentrations for priority pollutant parameters, excluding zinc, is provided in Table 4-12. It should be noted that zinc is also a naturally occurring analyte. Specifically concentrations of up to 0.05 mg/L are typical for both ground water and surface water (Environment Canada, 1979). Historical data for the site (prior to 1987) includes zinc concentrations that ranged from below detection limits to about 1.9 mg/L (Morrison Beatty Limited, 1988). Analysis for zinc was discontinued from the site monitoring program in 1987, presumably because the source of zinc (i.e. natural or landfill derived) could not be determined. Additional sampling and analysis, including monitoring wells (or private wells) upgradient of the site would be required to distinguish between background (naturally occurring) zinc and zinc attributable to the landfill site.

4.4.2 Potential Loadings to the Niagara River

Loading estimates for the Bridge Street Municipal Landfill Site are summarized in Table 4-11. Contaminant loadings to the Niagara River ranged from 0.0009 kg/day for the surface water migration pathway to 4.8126 kg/day for the bedrock migration pathway. The total potential loading to the Niagara River was estimated to be 4.8186 kg/day.

Total loading to the Niagara River from the historical analytical results for the Bridge Street Municipal Landfill Site was estimated to be 0.5 kg/day (Monenco, 1991), about an order of magnitude lower than the potential loading calculated from the 1993 analytical results. Historical loading estimates did not include ground water concentrations for the inorganic parameters detected in the samples collected in 1993. The discrepancy between the 1991 and 1993 potential loading estimates may be attributable to the analytes included in the calculation of total loading concentrations. For example, zinc, which contributes up to 97 percent to the total loading concentration calculated in 1993, was not included in the 1991 calculation. For comparison purposes, Table 4-12 lists the estimated potential loading of 1.454 kg/day, to the Niagara River excludes zinc.

The surface water migration pathway was identified by Monenco (1991) as the major contributor of loadings to the Niagara River from the site based on the historical analytical data. The pathway was estimated to contribute 98 percent of the total loading to the

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: POTENTIAL PRIORITY POLLUTANT LOADINGS TO THE NIAGARA RIVER BRIDGE STREET MUNICIPAL LANDFILL SITE (NO ZINC)

TABLE NUMBER: 4-12

SOURCE	CONCENTRATION *(mg/L)*		FLUX *(L/day)*	LOADING *(kg/day)*
GROUND WATER				
Bedrock	INORGANICS	0.3004	4665600	1.4015
	ORGANICS	0.0111	4665600	0.0518
	PATHWAY TOTAL			1.4534
Overburden	INORGANICS	0.0915	5702	0.0005
	ORGANICS	0.0100	5702	0.0001
	PATHWAY TOTAL			0.0006
	GROUND WATER PATHWAY TOTAL			1.4540
SURFACE WATER				
	INORGANICS	0.0184	1440	0.0000
	ORGANICS	0.0072	1440	0.0000
	SURFACE WATER TOTAL			0.0000
TOTAL LOADINGS				1.4540

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Notes:

1) Total loadings are presented to reflect the lowest concentration detected.

Niagara River from the site (Monenco, 1991). Based on the results of this study the total loading was calculated to be less than one percent. The loading discrepancy is attributable to the low flow condition observed during the 1993 sampling event. Also, historic surface water loading concentrations may be high. The annual monitoring results for the landfill site indicated that, excluding priority pollutants, parameter concentrations in surface water are similar upstream and downstream of the site along Miller Creek (Morrison Beatty Limited, 1991).

5.0 OTHER LANDFILL SITES WITHIN THE WATERSHED

A review of the twelve landfill sites that were classified by the NRTC as having less potential to contribute contaminant loadings to the Niagara River and the CN Rail Lands Victoria Avenue Landfill Site was also completed as part of this study. The review is based on: 1) reports prepared by various consultants for the site owners and the MOEE; and, 2) telephone communications with landfill operators and owners for pertinent information on area landfill sites. A summary table identifying each landfill site, its location, years of operation, refuse type, monitoring network details, and a summary of chemical analytical results, if available, is presented in Appendix E. In general no new data were available for the sites.

Ground water and surface water monitoring are conducted on a routine basis at the Glanbrook Municipal Landfill Site, the Binbrook Municipal Landfill Site, the Glanford Municipal Landfill Site and the Welland (Humberstone) Municipal Landfill Site. Routine monitoring is not performed at the other sites. Ground water monitoring has been proposed for the Fleet Industries Landfill Site in Fort Erie in conjunction with proposed remedial activities at the Fleet Industries Plant. Installation of monitoring wells and collection of ground water samples is also being undertaken at the CN Rail Lands Victoria Avenue Landfill Site in 1993.

In addition to the thirteen landfill sites noted by the NRTC, several sites not included in the list were identified during discussions with municipal officials. Although a review of the status of these landfill sites was beyond the scope of this study, the sites are listed below for information purposes.

SITE NAME	LOCATION	SITE NAME	LOCATION
Victoria Avenue Municipal Landfill Site	Niagara Falls	Stanley Avenue Municipal Landfill Site	Niagara Falls
Fairview Cemetery Landfill Site	Niagara Falls	Valley Way-Houck Park Landfill Site	Niagara Falls
Mountain Road Landfill Site	Niagara Falls	Montrose Road Landfill Site	Niagara Falls
Willoughby Municipal Landfill Site	Niagara Falls	Niagara Waste System Landfill Sites	Niagara Falls
Union Carbide Landfill Site	Welland	Riverside Drive & Lincoln St. Landfill Site	Welland
Atlas Specialty Steels Plant Site	Welland	Welland Forge Property	Welland
Panabrasives Inc. Landfill Site	Welland	Former Rice Road Landfill Site	Thorold
Former Winger Road Landfill Site	Fort Erie	Elm Street Landfill Site	Port Colborne
Perry Street Landfill	Wainfleet	Caister Centre Landfill Site	Smithville
James Road Transfer Station and Former Landfill Site	Region of Haldimand-Norfolk		

6.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the 1993 findings provided in this report, the following conclusions are presented.

- The Niagara River Toxic Committee (NRTC) Parameter of Concern detected at the four Ontario landfill sites sampled are limited to those listed below.

LANDFILL SITE	NRTC PARAMETER OF CONCERN DETECTED	COMMENT
Cyanamid Canada Inc. Niagara Falls Landfill Sites	lead	Downgradient ground water concentrations ranged from not detected to 0.006 mg/L. Lead was also detected in downstream surface water at trace concentrations.
	mercury	Mercury was detected in trace concentrations (up to 0.04 mg/L) in one overburden ground water sample and in the surface water sample.
		Additional sampling would be required to confirm the occurrence and concentration of lead and mercury in water at the site.

LANDFILL SITE	NRTC PARAMETER OF CONCERN DETECTED	COMMENT
Cyanamid Canada Inc. Welland Landfill Site	lead	Lead was detected in ground water in concentrations ranging from 0.052 to 0.084 mg/L. The surface water concentration of lead decreased from upstream to downstream of the site.
	hexachlorobenzene	Detected in trace concentrations in the overburden ground water sample. Additional sampling and analysis is required to confirm occurrence and concentration of hexachlorobenzene and lead at the site.
Atlas Specialty Steels Landfill Site	mercury	Detected at trace concentrations (0.03 mg/L) in a duplicate surface water sample.
	lead	Detected in concentrations up to 0.062 mg/L in ground water. Also detected in surface water, albeit at reduced concentrations.
	hexachlorobenzene	Detected in trace concentrations (up to 0.000007 mg/L) in one ground water sample and the surface water sample.
	tetrachloroethylene	Detected in trace concentrations (0.0005 mg/L) in a duplicate surface water sample. Additional sampling and analysis required to confirm occurrence and concentrations of parameters of concern at the site.

LANDFILL SITE	NRTC PARAMETER OF CONCERN DETECTED	COMMENT
Bridge Street Municipal Landfill Site	lead	Detected in bedrock ground water and sample collected from below the waste.
	hexachlorobenzene	Detected in trace concentrations in sample collected from below the waste.
	chlordane	Detected in trace concentrations in sample collected from below the waste.
		Additional sampling and analysis would be required to confirm occurrence and concentrations of parameters of concern.

- Priority pollutants were detected at all four Ontario Landfill Sites sampled in 1993. Inorganic priority pollutant concentrations account for between 35 percent and 90 percent of the total analyte concentrations at the landfill sites.

- Organic priority pollutants account for less than 10 percent of the total parameter concentrations at all landfill sites with the exception of the Cyanamid Canada Inc. Welland Landfill Site. At this site the organic concentrations in surface water account for about 68 percent of the total loading concentration.

- Surface water distributes the majority of the priority pollutant loading to the Niagara and Welland Rivers relative to ground water.

- The 1993 potential contaminant loadings to the Niagara River as calculated using the method attributed to Gradient Corporation and GeoTrans, Inc. (1988) are as follows:

LANDFILL SITE	1993 POTENTIAL CONTAMINANT LOADING
Cyanamid Canada Inc. Niagara Falls Landfill Sites	6.4176 kg/day
Cyanamid Canada Inc. Welland Landfill Site	0.3677 kg/day
Atlas Specialty Steels Landfill Site	0.0543 kg/day
Bridge Street Municipal Landfill Site	4.8186 kg/day
Total Loading From Ontario Based Landfill Sites	**11.6582**

7.0 REFERENCES

1) Dames & Moore, Canada, 1992; *1991 Annual Monitoring Report for the Bridge Street Landfill Site, Town of Fort Erie*, Prepared for The Town of Fort Erie; 22pp and appendices.

2) Environment Canada, 1979; *Water Quality Sourcebook - A Guide to Water Quality Parameters*; Inland Waters Directorate, Water Quality Branch, Ottawa. 73pp.

3) Environmental Strategies Limited, 1992; *Volume II, Appendices II-A and II-B, Ground Water Modelling and Risk Assessment Studies, Cyanamid/Ontario Hydro Landfill Sites, Niagara Falls, Ontario*; Prepared for Cyanamid Canada Inc. and Ontario Hydro, 87pp and appendices.

4) Gartner Lee Limited, 1986; *Cyanamid Canada Inc. Niagara Plant, Hydrogeological Investigation Phase I, Volume I;* Prepared for Cyanamid Canada Inc., Ontario Hydro and the Ministry of the Environment, 69pp and appendices.

5) Gartner Lee Limited, 1986; *Cyanamid Canada Inc. Niagara Plant, Hydrogeological Investigation Phase I, Volume II, Appendix I & II;* Prepared for Cyanamid Canada Inc. and Ontario Hydro, 263pp.

6) Gartner Lee Limited, 1988; *Cyanamid Canada Inc. Niagara Plant, Hydrogeological Investigation Phase II(b) Volume 1 Report and Toxicological Assessment*; Prepared for Cyanamid Canada Inc. and Ontario Hydro, 63pp and appendices.

7) Gartner Lee Limited, 1988; *Cyanamid Canada Inc. Niagara Plant, Hydrogeological Investigation Phase II(b) Volume 2 - Appendices*; Prepared for Cyanamid Canada Inc. and Ontario Hydro, 177pp.

8) Gartner Lee Limited, 1990; *Cyanamid Canada Inc. Niagara Plant, Hydrogeological Investigation Phase II(c)*; Prepared for Cyanamid Canada Inc. and Ontario Hydro, 37pp and appendices.

9) Gradient Corporation and GeoTrans, Inc., 1988; *Potential Contaminant Loadings to the Niagara River From U.S. Hazardous Waste Sites*; 2 Volumes.

10) Ministry of the Environment, 1992a; *Request for Proposal Environmental Investigation - Ontario Based Landfills;* July 3, 1992.

11) Ministry of the Environment, 1992b; *Provincial Water Quality Objectives and Guidelines;* October 1992.

12) Ministry of the Environment, 1992c; *Ontario's Drinking Water Objectives;* In Environment Information, Summer 1992

13) Ministry of the Environment and Energy, personal communication, 1993; *Chemicals of Concern in the Niagara River* (Table).

14) Monenco Ontario Limited, 1981; Excerpts *Industrial Waste Site Identification Study, Part I, Site Investigations, West-Central Regions - Final Report*; Prepared for the Ministry of the Environment, 38pp.

15) Monenco Ontario Limited, 1981; *Ontario Ministry of the Environment - Industrial Waste Site Identification Study, Part I, Site Investigations, West-Central Regions - Final Report, Volume 1*; Prepared for the Ministry of the Environment, 160pp.

16) Monenco Ontario Limited, 1981; *Ontario Ministry of the Environment - Industrial Waste Site Identification Study, Part I, Site Investigations, West-Central Regions - Final Report, Volume 2*; Prepared for the Ministry of the Environment, 154pp.

17) Monenco Consultants Limited, 1991; *Potential Contaminant Loadings to the Niagara River from Canadian Waste Disposal Sites*; Prepared for the Ministry of the Environment, 49pp and appendices.

18) Morrison Beatty Limited, 1988; *Hydrogeological Impact Studies for the Bridge Street Landfill Site - Town of Fort Erie*; Prepared for the Town of Fort Erie, 95pp and appendices.

19) Morrison Beatty Limited, 1990; *1989 Annual Monitoring Report for the Bridge Street Landfill Site - Town of Fort Erie*; Prepared for the Town of Fort Erie, 29pp and appendices.

20) Morrison Beatty Limited, 1991; *1990 Annual Monitoring Report for the Bridge Street Landfill Site - Town of Fort Erie*; Prepared for the Town of Fort Erie, 26pp and appendices.

21) The Niagara River Toxics Committee, 1984; *Report of the Niagara River Toxics Committee*; 378pp and appendices.

APPENDIX A

APPENDIX A

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A1.0 CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES

A1.1 SITE LOCATION

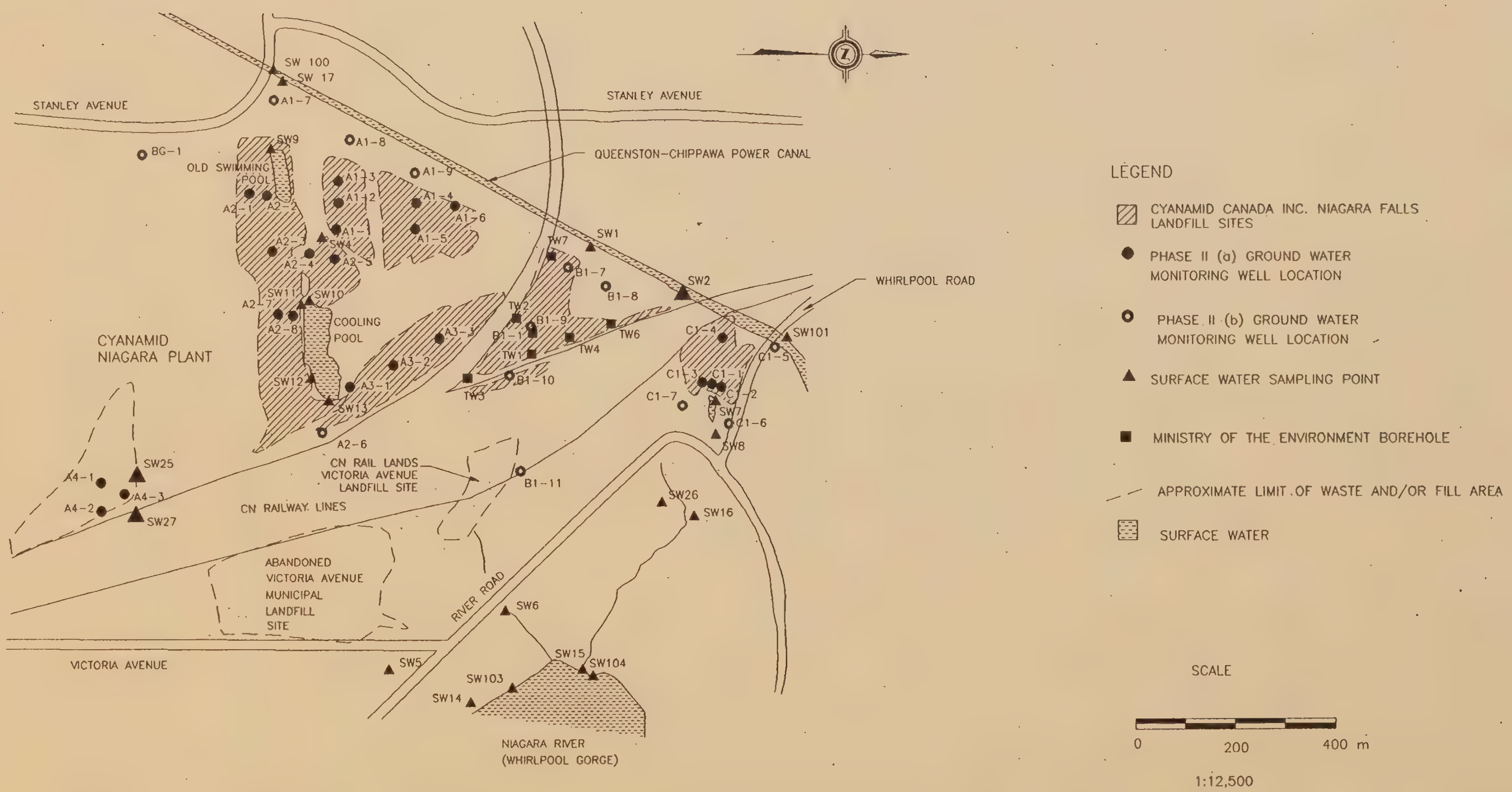
The Cyanamid Canada Inc. Niagara Falls Landfill Sites are located west of the Whirlpool Gorge, east of the Queenston-Chippawa Power Canal, south of the junction of the Power Canal and the CN Railway lines, and north of Cyanamid Canada Inc.'s Fourth Avenue Plant in the City of Niagara Falls. The landfill site locations are shown in Figure A1-1.

Between the 1940s and 1960s Cyanamid Canada Inc. used lands around its Niagara Falls Plant, including lands leased from Ontario Hydro, to dispose of cyanide bearing wastes from the production of calcium carbide and calcium cyanamide. Wastes disposed include lime, carbon, slaked lime, calcium carbide ash, calcium carbonate, calcium oxide, bricks, coke and limestone dust. In 1979 the wastes placed on Ontario Hydro property were reportedly excavated to ground level and transferred to a disposal area at the Cyanamid Canada Inc., Welland Plant. However, it is estimated that approximately 7.5 x 10^4 cubic metres of process wastes are still present on Ontario Hydro property.

Three distinct disposal areas have been identified through recent investigation of the Cyanamid Canada Inc. Niagara Falls landfill operation. The sites have been identified as Areas A, B and C, which generally correspond to three ancestral drainage pathways that are infilled to varying degrees with waste materials such as coke and lime and native soil backfill generated during the construction of the Ontario Hydro Power Canals. Area A includes land abutting the eastern and northern edge of the Cyanamid Canada Inc. Niagara Falls Plant and the abandoned Victoria Avenue Landfill owned by CN Railway and leased by the City of Niagara Falls. Area B is owned by Ontario Hydro and CN Railway and includes the CN Rail Victoria Avenue Landfill Site, while Area C is largely owned by Ontario Hydro.

A1.2 GENERAL SITE GEOLOGY AND HYDROGEOLOGY

The Cyanamid Canada Inc. Niagara Falls Landfill Sites are underlain by glaciolacustrine silt and sand, and clayey and silty till. It is understood that in the general vicinity of the landfill sites the glacial overburden material is about 12 to 16 metres thick, with the exception of



(MODIFIED FROM GARTNER LEE LIMITED, 1988)

/192039/FIG2-1

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FIGURE A1–1

HISTORICAL SAMPLING LOCATIONS
CYANAMID CANADA INC. NIAGARA FALLS
LANDFILL SITES

Area C in the vicinity of the buried St. Davids Gorge. Overburden in the buried St. Davids Gorge, located east of Area C, is about 100 metres thick.

Ground water flow on the Cyanamid Canada Inc. Niagara Falls Landfill Sites property is reportedly complex being influenced by ancestral drainage patterns and recent manmade structures such as cooling ponds and the Queenston-Chippawa Power Canal. Specifically, shallow ground water flow in Area A is eastward, with a small component of flow westward toward the Queenston-Chippawa Power Canal. Relatively steep vertical hydraulic gradients have been observed throughout Area A, and subsequently most shallow ground water flow is suspected to be downward towards bedrock (Gartner Lee Limited, 1988). In the bedrock below Area A, flow is lateral in a westerly direction to the Queenston-Chippawa Power Canal at an estimated rate of about 1700 metres/year.

In Area B, shallow ground water flow is predominantly northwesterly towards the Queenston-Chippawa Power Canal, with a small component of flow to the Niagara Gorge and vertically downwards to bedrock. Ground water flow in the top portions of bedrock is towards the northwest at rates estimated in the order of 2300 metres/year (Gartner Lee Limited, 1988).

Ground water flow in the shallow overburden in Area C is predominantly downward at rates of about 180 metres/year (Gartner Lee Limited, 1990) with a small lateral component of flow lateral to the Queenston-Chippawa Power Canal and the buried St. Davids Gorge. In the top portion of bedrock, ground water flow is lateral towards the Power Canal and the buried St. Davids Gorge.

A1.3 EXISTING WATER MONITORING NETWORK

The monitoring well network at the Cyanamid Canada Inc. Niagara Falls Landfill Sites consists of 39 well nests installed in 1987 and 1988. The monitoring well locations are shown in Figure A1-1. There are up to 4 monitoring wells in each nest, for a total of 86 separate monitoring wells. The monitoring wells are constructed of 51 mm ID, Schedule 80, PVC pipe with 10 slot PVC screens. No PVC glue or cement was used in construction of the monitoring wells. All have lockable steel protective casings.

A1.4 HISTORICAL CHEMISTRY DATA BASE

A substantial amount of historical chemistry data are available for the Cyanamid Canada Inc. Niagara Falls Landfill Sites. The data were collected between 1986 and 1990 as part of the phased Hydrogeologic Study of the Landfill Sites performed by Gartner Lee Limited for Cyanamid Canada Inc. and Ontario Hydro.

TABLE A1-1 SUMMARY OF WATER SAMPLING ANALYSIS - CYANAMID CANADA INC. - NIAGARA FALLS LANDFILL SITES

DATE	NUMBER OF MONITORING STATIONS	ANALYSIS PERFORMED
1984 (1 event)	7 monitoring wells 4 surface water stations	general chemistry and nutrients cyanide, heavy metals (2 wells only)
1986 (2 events)	16 surface water stations 16 monitoring wells	general chemistry, nutrients cyanide
1987 (12 events)	23 surface water stations	general chemistry, nutrients, cyanide
1987 (2 events)	72 monitoring wells	general chemistry, nutrients, cyanide
1988	72 monitoring wells	general chemistry, nutrients, cyanide
1989 (2 events)	75 monitoring wells	general chemistry, nutrients, cyanide, metals, heavy metals volatile organic compounds (1 event, 16 wells only) semi volatile organic compounds (1 event, 16 wells only)

It is not known whether annual monitoring continues at the site. However, Gartner Lee Limited (1990) recommended that ground water monitoring continue in 1990 at a frequency of once per year. It was also recommended that the monitoring program include analysis for free and total cyanide, nutrient parameters nitrate and ammonia, general chemistry and ICAP metals.

A2.0 CYANAMID CANADA INC. WELLAND LANDFILL SITE

A2.1 SITE LOCATION

The Cyanamid Canada Inc. Welland Landfill Site is located on the northwest corner of Garner Road and Chippawa Creek Drive, immediately north of the Welland River, on the border between the City of Niagara Falls and the City of Welland (Figure A2-1). The site consists of two disposal areas designated and described as follows (Gartner Lee Limited, 1988):

DESIGNATION	DESCRIPTION OF WASTE
The West Dump Site	Non-hazardous waste including floor sweeping, fly ash, drums, wood and filter material.
Sludge Basins	Calcium oxide-calcium carbonate slurry mixed with acid waste. Cyanide contaminated solid waste.

A2.2 GENERAL SITE GEOLOGY AND HYDROGEOLOGY

The Cyanamid Canada Inc. Welland Landfill Site property is underlain by a sequence of stratified lacustrine clayey silt to a depth of 9 to 15 metres, a sandy silt till unit and dolomitic limestone bedrock. Bedrock depth on-site ranges between 15 and 20 metres below ground surface.

Vertical downward hydraulic gradients are reported across the site (Gartner Lee Limited, 1988), with the exception of the upper 3 to 5 metres of lacustrine clayey silt which constitutes the weathered zone. Downward hydraulic gradients ranging from 6×10^{-2} to 3×10^{-1} metres/year are reported for overburden materials below the weathered zone. Flow in the weathered zone is reported to be primarily horizontal through desiccation cracks and fractures.

Based on water level measurements in the waste (Gartner Lee Limited, 1988), ground water flow is outward from the sludge basins at an estimated rate of a few metres per year. A ground water divide, trending east-west across The West Dump Site is present resulting in ground water movement in the shallow subsurface in the vicinity of The West Dump Site, towards Thompson Creek to the north and the Welland River to the south.

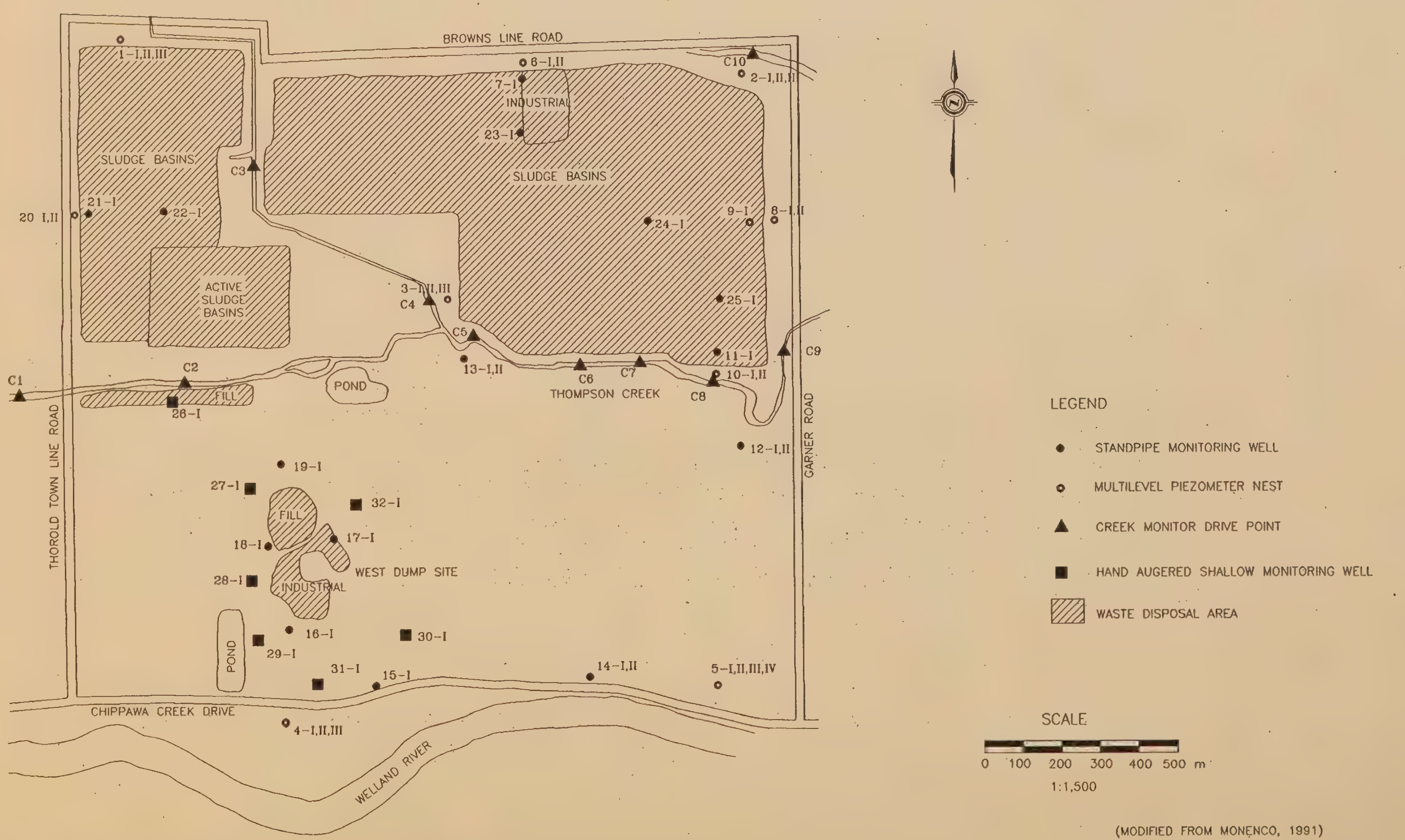

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FIGURE A2-1

HISTORICAL SAMPLING LOCATIONS
CYANAMID CANADA INC.
WELLAND LANDFILL SITE

Ground water flow in the bedrock is laterally to the south at a rate of about 9 metres/year. The main component of flow in the bedrock occurs in the upper 3 to 5 metres of rock. The upper bedrock surface is estimated to have a hydraulic conductivity of about 100 metres/year (Gartner Lee Limited, 1986).

Water level data for monitoring wells adjacent to Thompson Creek in the area south of the sludge basins, suggest a vertical upward hydraulic gradient to the creek.

Data from the 1985 to 1988 investigations at the Welland Plant conducted by Gartner Lee Limited suggest that contaminant migration is likely restricted to: (1) the upper weathered portion of the glaciolacustrine unit; (2) the granular filled trenches surrounding sewer piping originating from the Cyanamid Canada Inc. Welland Plant; and, (3) the surface sandy fill of old tailing material near The West Dump Site.

A2.3 EXISTING WATER MONITORING NETWORK

The monitoring well network includes 43 monitoring wells installed by Gartner Lee Limited in 1984 at 25 locations on-site, and an additional 21 monitoring stations which were added in 1987. The 1987 stations included four monitoring wells completed in the sludge basins at the north end of the property (to a maximum depth of 8 metres), ten shallow creek monitors into the bed of Thompson Creek (to an approximate depth of 0.8 metres into the creek bed) and seven shallow wells installed in the fill material at The West Dump Site. Monitoring well locations are shown in Figure A2-1.

Monitoring wells are reportedly sampled using individually dedicated 0.6 mm ID polyethylene tubing. It is not known whether the tubing is still in place in the wells or whether it is suitable for use.

A2.4 HISTORICAL CHEMISTRY DATA BASE

The historical chemistry data base for the Cyanamid Canada Inc. Welland Landfill Site includes analytical results for water samples collected in 1985 and 1986. A summary of the data base is provided in Table A2-1 below.

TABLE A2-1 SUMMARY OF WATER SAMPLING ANALYSIS - CYANAMID CANADA INC. WELLAND LANDFILL SITE

DATE	NUMBER OF MONITORING STATIONS	ANALYSIS PERFORMED
August 1985	43 monitoring wells	general chemistry, inorganics, metals, nutrients
October 1985	10 surface water stations	general chemistry, inorganics, metals, nutrients
November 1985	45 monitoring wells 10 surface water stations	general chemistry, inorganics, metals, nutrients
March 1986	48 monitoring wells 10 surface water stations	general chemistry, inorganics, metals, nutrients
June 1986	48 monitoring wells 8 surface water stations	general chemistry, inorganics, metals, nutrients

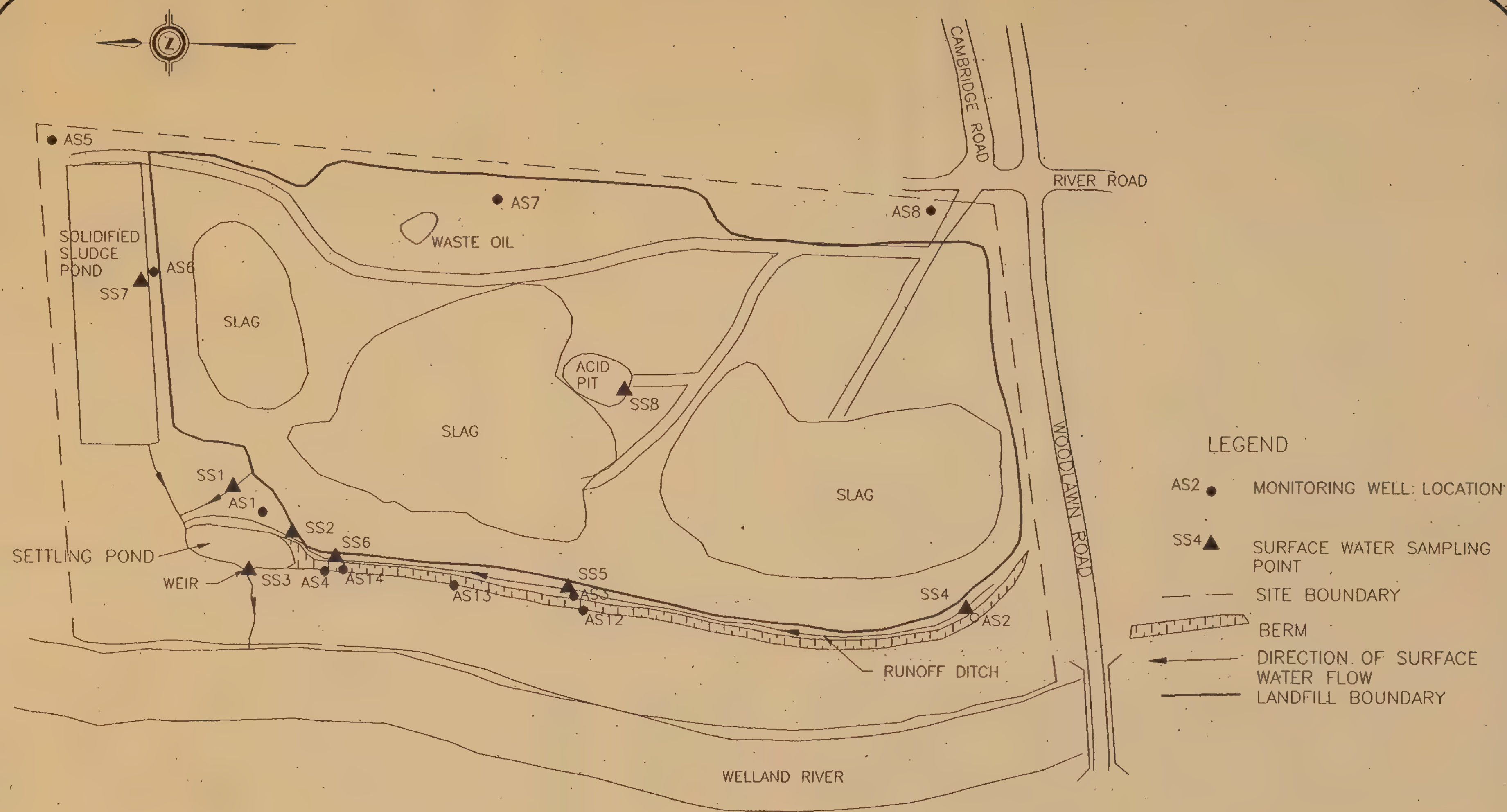
The organic analyses were included in the 1985/1986 sampling program. It is not known whether sampling and analysis of water has been conducted at the Cyanamid Canada Inc. Welland Landfill Site since 1986. However, Gartner Lee Limited in its August 1987 *Phase II Hydrogeologic Study Report* recommended that a long-term ground water monitoring program be initiated at the site. The proposed monitoring program included annual collection of samples and analysis for indicator parameters nitrate, ammonia, sulphate, fluoride, and total and free cyanide.

A3.0 <u>ATLAS SPECIALTY STEELS LANDFILL SITE</u>

A3.1 SITE LOCATION

The Atlas Specialty Steels Landfill Site is located north of Woodlawn Road and west of River Road in the City of Welland. The 17.7 hectare site is located east of the Welland River as shown in Figure A3-1.

The Atlas Specialty Steels Landfill Site is operated under Provisional Certificate of Approval No. A120409 (issued in 1980). The site is licensed to accept 125 to 150 tonnes of



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(MODIFIED FROM MONENCO, 1991)

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FIGURE A3-1
HISTORICAL SAMPLING LOCATIONS
ATLAS SPECIALTY STEELS
LANDFILL SITE

non-hazardous solid industrial wastes per day. The Atlas Specialty Steels Landfill Site has been in use since the 1930s. From the early 1930s to the 1980s the site accepted electric furnace slag, baghouse dust, broken concrete, refractory rubble and acid waste from the Atlas Specialty Steels plant in Welland, Ontario. In 1984, when a waste acid solidification neutralization plant was constructed at the Atlas Specialty Steels plant, the on-site disposal of waste acid was discontinued. Previously landfilled acid wastes were reportedly excavated and sent to the solidification plant for treatment.

A clay berm was installed at the toe of the landfill site in 1982 as shown in Figure A3-1. Runoff and leachate are directed to a settling pond in the northwest corner of the site. The settling pond is connected to a concrete weir which overflows to the Welland River.

Within the landfill site, wastes are placed up to 10 metres above ground surface in accordance with the site contouring plan. The plan allows for the placement of 20 to 30 metres of waste at a slope of 45 degrees (i.e. 1:1 ratio). Contouring slopes from west to east across the site to direct surface water runoff and flow away from the Welland River.

A3.2 GENERAL SITE GEOLOGY AND HYDROGEOLOGY

The geology and hydrogeologic information for the Atlas Specialty Steels Landfill Site is primarily limited to the overburden. The site is underlain by between 15 and 30 metres of native clay material and a thin (1 to 2 metre thick) intermittent seam of gravel, sand or gravelly clay. Bedrock in the area is the Guelph Formation dolostone.

Ground water flow in the on-site overburden is westward towards the Welland River at a rate of between 0.02 and 0.25 metres/year (Monenco, 1991). Hydraulic conductivities ranging between 0.03 metres/year and 31.5 metres/year are typical of the unweathered soils beneath the site. Hydraulic conductivities of up to 0.03 metres/year are estimated for the upper few metres of weathered and fractured clay overburden.

A3.3 EXISTING WATER MONITORING NETWORK

The monitoring well network on-site consists of eight monitoring wells installed in 1984 and six monitoring wells installed in 1986 by Terraqua Investigations Limited. The monitoring wells are designated AS1 to AS14. The locations are shown in Figure A3-1.

A single monitoring well is completed at the bedrock/overburden interface at a depth of about 22.5 metres below ground surface. The remainder of the wells are completed in overburden at depths ranging from about 5 to 10 metres below ground surface.

Limited information is available regarding construction of the monitoring wells. The summary table included in Appendix B was completed based on borehole logs provided by Atlas Specialty Steels.

A3.4 HISTORICAL CHEMICAL DATA BASE

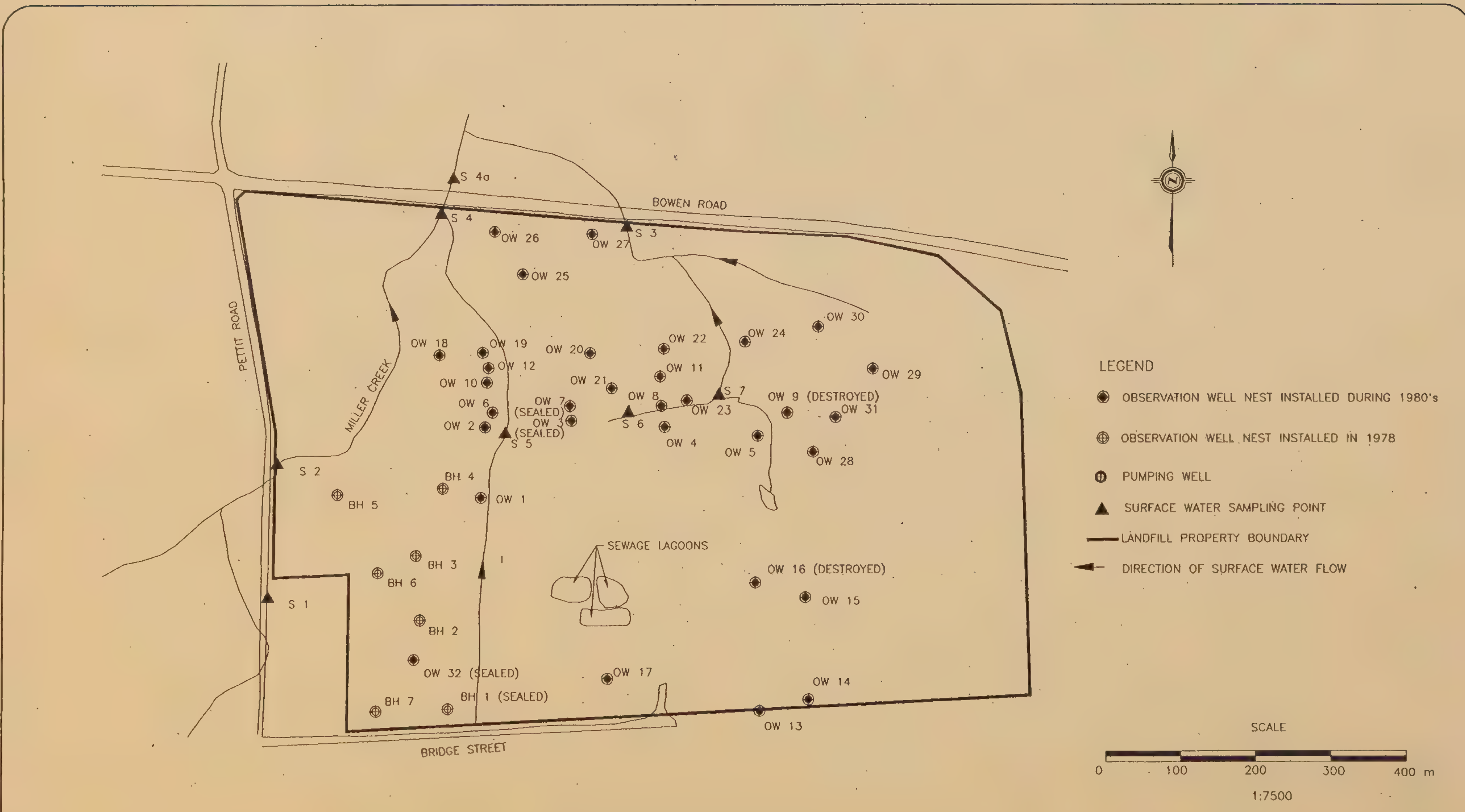
There is a limited historical chemical data base for the Atlas Specialty Steels Landfill Site. In 1984/1985, water samples were collected from 17 monitoring wells and 5 surface water sampling stations for analysis of inorganic parameters, heavy metals, nitrates and cyanide. Additionally, a composite effluent sample was collected monthly between March 1985 and April 1986, and analysed for 10 parameters including pH, suspended solids, free oil and grease, and selected heavy metals (Atlas Specialty Steels Division, 1986).

There are no organic chemistry data available for this site. Additionally, it is not known whether sampling of ground water at the site has been conducted since 1986.

A4.0 TOWN OF FORT ERIE BRIDGE STREET MUNICIPAL LANDFILL SITE

A4.1 SITE LOCATION

The Town of Fort Erie, Bridge Street Municipal Landfill Site, is located on Lot 7, Concession 4 in the former Township of Bertie, Regional Municipality of Niagara. The site, shown in Figure A4-1, has been in operation as a municipal landfill site since 1972. The site is licensed to accept primarily non-hazardous, residential and commercial wastes. Reportedly, the landfill site receives 50 percent residential waste, 30 percent commercial waste, 5 percent industrial waste (non-hazardous), 5 percent municipal sewage sludge and 10 percent wood and construction debris.



(MODIFIED FROM MORRISON BEATTY LIMITED, 1988)

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FIGURE A4-1
HISTORICAL SAMPLING LOCATIONS
BRIDGE STREET MUNICIPAL LANDFILL SITE

Prior to 1972 the site was privately operated. There is no record of liquid waste or hazardous industrial waste disposal at the landfill site. Several industries in the Fort Erie area reportedly use the landfill for the disposal of a variety of waste products, including cardboard, wooden pallets, empty drums, containers, outdated paints, paint sludges, and waste resins and mouldings. Waste resins include solid and liquid phenol formaldehyde resins, and caustic sludge. Drums deposited between 1974 and 1979, contain solid waste of unknown composition.

In 1989, a three-year Certificate of Approval to expand the waste disposal area onto a 4 hectare parcel to the north of the existing fill area was issued to the Town of Fort Erie. The landfill expansion was approved as an interim disposal site until longer term waste disposal capacity is obtained by the Town. In February 1992 the Town applied for a new Certificate of Approval to continue using the Bridge Street Municipal Landfill Site for five additional years. The application was approved in January 1993.

A4.2 GENERAL SITE GEOLOGY AND HYDROGEOLOGY

The Bridge Street Municipal Landfill Site is underlain by a sequence of glaciofluvial sand, silt and clay, and silt till. The overburden thickness is between 3 and 10 metres. Bedrock in the area is the Salina Formation dolostone.

The Onaganda Escarpment is located in the general vicinity of the Bridge Street Municipal Landfill Site. Overburden thickness generally increases to the north, from about 2.4 metres near the south end of the site to 10.5 metres north of the existing landfill.

Ground water movement is generally northward from the site. A component of flow is downward through the overburden to the bedrock. The average ground water velocity is estimated to be 0.5 metres/year (Morrison Beatty Limited, 1988). Overburden potentiometric maps for the site suggest that a portion of the overburden ground water discharges to the small tributaries of Miller Creek at the north end of the site. Downward hydraulic gradients are observed between the overburden and bedrock along the north face of the landfill and north of the site near Bowen Road, and the north and northeast sides of the landfill.

The water level has historically fluctuated from a seasonal low in the fall (September and October) to a seasonal high in the spring (March and April). Water levels within bedrock wells tend to fluctuate more dramatically and rapidly than overburden water levels. Water level fluctuations range between 1 and 2.5 metres throughout the year.

Surface water drainage in the vicinity of the Bridge Street Municipal Landfill Site is through the northerly flowing Miller Creek and its tributaries. Drainage ditches discharge to the northwest and northeast corners of the site and into Miller Creek.

A4.3 EXISTING WATER MONITORING NETWORK

The monitoring network includes a total of 78 wells installed at 34 locations between 1981 and 1991. Monitoring wells installed prior to 1986 (designated as OW1 to OW16) are generally constructed of 40 mm diameter ABS pipe with a hand slotted screen, while those installed after 1986 are generally constructed of 50 mm diameter PVC pipe, with a 10 Slot PVC screen.

Surface water at the Bridge Street Municipal Landfill Site is reportedly sampled on a monthly basis at seven locations shown in Figure A2-4. Samples are not normally obtained at all surface water sampling stations in the winter months, due to frozen conditions. Additionally, many of the surface water sampling stations are dry during the summer months.

A4.4 HISTORICAL CHEMICAL DATA BASE

Ground water sampling has been conducted at the Bridge Street Municipal Landfill Site since 1981. The monitoring program generally includes sampling and analysis for general chemistry, inorganic chemical parameters, metals and organic compounds and is summarized in Table A4-1, below.

TABLE A4-1 SUMMARY OF WATER SAMPLING ANALYSIS - BRIDGE STREET MUNICIPAL LANDFILL SITE

DATE	NUMBER OF MONITORING STATIONS	ANALYSIS PERFORMED
1981 (1 event)	11 monitoring wells	general chemistry, inorganics bulk organics
1982 (1 event)	3 monitoring wells	general chemistry, selected inorganics bulk organics, metals, bacteriological analysis, pesticides
1983 (1 event)	12 monitoring wells	general chemistry, inorganics bulk organics
1984 (1 event)	20 monitoring wells	general chemistry, inorganics bulk organics, volatile organics
1986 (2 events)	32 monitoring wells	general chemistry, inorganics bulk organics, volatile organics
1987 (2 events)	50 monitoring wells	general chemistry, inorganics bulk organics
1987 (2 events)	25 monitoring wells	general chemistry, inorganics bulk organics, iron and manganese
1988-1989 (3 events)	31 monitoring wells	general chemistry, inorganics bulk organics, volatile organics iron and manganese
1990 (3 events)	37 monitoring wells	general chemistry, inorganics bulk organics, volatile organics, iron and manganese
1991 (2 events)	36 monitoring wells	general chemistry, inorganics bulk organics, volatile organics iron and manganese

APPENDIX B

- TABLE B1-1: WATER LEVEL OBSERVATIONS
- TABLE B1-2: PURGING DETAILS
- TABLE B1-3: CALCULATION OF SURFACE WATER FLUX - CYANAMID INC. NIAGARA FALLS LANDFILL SITES
- TABLE B1-4: CALCULATION OF SURFACE WATER FLUX - ATLAS SPECIALTY STEELS LANDFILL SITE

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: WATER LEVEL OBSERVATIONS

TABLE NUMBER: B1-1

Landfill Site	Monitoring Well	Elevation (Top of Pipe) (m a.s.l.)	Water Level (m b.t.o.p.)	Water Elevation (m a.s.l.)
Cyanamid Canada Inc. Niagara Falls Landfill Sites	BG-1-I	185.31	10.93	174.38
	BG-1-II	185.32	8.74	176.58
	A1-8-I	182.48	12.79	169.69
	C1-4-II	179.9	6.48	173.42
	C1-5-I	178.83	10.7	168.13
	B1-10-II	179.84	2.25	177.59
Cyanamid Canada Inc. Welland Landfill Site	5-I	NA	1.98	NA
	5-IV	NA	2.34	NA
	23-I	NA	1.04	NA
Atlas Specialty Steels Landfill Site	AS12	NA	1.9	NA
	AS13	NA	2.37	NA
	AS14	NA	2.18	NA
Bridge Street Municipal Landfill Site	OW 17-6	188.51	3.45	185.06
	OW 23-5	182.97	3.15	179.82
	OW 29-14	181.28	8.02	173.26

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Notes:

m a.s.l metres above sea level
m b.t.o.p. metres below top of pipe

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: PURGING DETAILS
TABLE NUMBER: B1-2

Landfill Site	Monitoring Well	Inital Standing Volume (L)	Volume of Water Removed (L)	Total Number of Casing Volumes Removed	Field Parameters			
					pH	Specific Conductance (uS/cm)	Temperature (C)	Turbidity
Cyanamid	BG-1-I	48.4	15.0	0.3	6.52	2450	9.0	cloudy, light brown; fine sand sediment
Canada Inc.			12.0	0.6	6.89	2610	8.6	cloudy, light brown; fine sand sediment
Niagara Falls			6.0	0.7	NM	NM	NM	NM
Landfill Sites			8.0	0.8	7.03	2560	9.3	slightly cloudy; no sand
			5.0	1.0	NM	NM	NM	slightly cloudy
			9.0	1.1	7.07	2510	9.5	clear
	BG-1-II	39.9	4.0	0.1	7.01	803	9.3	cloudy, orange-brown
			6.0	0.3	NM	NM	NM	cloudy; heavy fine sand sediment load
			6.0	0.4	NM	NM	NM	cloudy; heavy fine sand sediment load
			11.5	0.7	7.23	782	8.5	cloudy; heavy fine sand sediment load
			5.5	0.8	7.39	800	9.5	cloudy; heavy fine sand sediment load
			6.5	1.0	7.43	800	8.9	cloudy; heavy fine sand sediment load
	A1-8-I	15.2	13.0	0.9	8.85	1861	9.0	cloudy, grey-brown; H2S odour
			11.5	1.6	8.85	2350	8.2	cloudy, light brown; H2S odour
			10.0	2.3	8.68	3220	9.2	cloudy, light brown; H2S odour
			11.0	3.0	8.92	2370	8.9	cloudy, light brown; H2S odour
	C1-4-II	25.3	10.0	0.4	12.23	2740	6.7	very silty; dark orange brown; ammonia odour
			7.0	0.7	12.23	2330	5.2	very silty; dark orange brown; ammonia odour
			5.0	0.9	12.51	2400	8.7	very silty; dark orange brown; ammonia odour
	C1-5-I	18.6	15.0	0.8	9.44	1555	9.5	light brown; H2S odour
			14.0	1.6	9.44	1601	9.2	light brown; H2S odour
			14.0	2.3	9.45	1618	9.1	light brown; H2S odour
			14.0	3.1	9.62	1739	9.3	light brown; H2S odour
	B1-10-II	29.0	8.5	0.3	9.58	3300	NM	cloudy; brown; well purged to dryness
Cyanamid	5-I	29.6	4.0	0.1	6.87	2400	9.5	cloudy; light grey; H2S odour
Canada Inc.			21.0	0.8	6.97	1608	9.6	cloudy; light grey; H2S odour
Welland			24.0	1.7	7.00	1656	9.6	cloudy; light grey; H2S odour
Landfill Site			31.0	2.7	6.98	1613	9.5	cloudy; light grey; H2S odour
	5-IV	10.2	1.5	0.1	6.76	1848	8.3	slightly cloudy; light brown
			6.5	0.8	6.68	1730	7.7	slightly cloudy; light brown
			11.0	1.9	7.21	1200	8.5	slightly cloudy; light brown
			4.0	2.3	7.39	1333	8.8	slightly cloudy; light brown
			0.5	2.3	NM	NM	NM	slightly cloudy; light brown
	23-I	18.6	10.0	0.5	11.31	5520	9.3	clear; yellow colour; ammonia odour
			9.0	1.0	11.17	5520	9.5	clear; yellow colour; ammonia odour
			18.0	2.0	10.87	6230	10.0	clear; yellow colour; ammonia odour
			18.0	3.0	11.17	5840	9.4	clear; yellow colour; ammonia odour

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Notes:
NM Parameter Not Measured

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: PURGING DETAILS

TABLE NUMBER: B1-2

Landfill Site	Monitoring Well	Inital Standing Volume (L)	Volume of Water Removed (L)	Total Number of Casing Volumes Removed	Field Parameters			
					pH	Specific Conductance (uS/cm)	Temperature (C)	Turbidity
Atlas Specialty Steels Landfill Site	AS12	24.4	5.0	0.2	6.92	7040	5.9	grey-black turbid; H2S odour; grey scum
			4.0	0.4	6.69	5880	6.8	grey-black turbid; offensive odour; grey scum
			5.0	0.6	6.89	6570	7.1	grey-black turbid; H2S odour; grey scum
			3.0	0.7	6.64	6580	6.6	grey-black turbid; H2S odour; grey scum
			1.0	0.7	NM	NM	NM	grey-black turbid; H2S odour; grey scum
	AS13	20.9	1.0	0.0	6.43	6680	8.4	clear with small black particles
			10.0	0.5	6.43	6950	8.7	clear with small black particles; slight H2S
			4.0	0.7	NM	NM	NM	NM
			1.5	0.8	6.86	6880	8.5	cloudy; light brown; no odour
	AS14	24.0	1.0	0.0	7.04	NM	8.0	cloudy; light brown
			7.5	0.4	7.08	NM	7.0	cloudy; light brown; some fine sand
			4.0	0.5	6.84	5120	6.0	cloudy; light brown; some fine sand
			6.0	0.8	6.94	4950	6.1	cloudy; light brown; some sand
			5.5	1.0	6.98	4810	7.2	cloudy; light brown; no sand
Bridge Street Municipal Landfill Site	OW 17-6	20.1	4.0	0.2	7.08	1945	7.9	slightly opaque; light brown
			4.0	0.4	7.04	1955	8.4	cloudy; light brown
			9.0	0.8	6.91	2100	8.5	cloudy; light brown
			3.0	1.0	NM	NM	NM	NM
	OW 23-5	26.5	2.0	0.1	6.50	1960	7.4	cloudy; grey brown; slightly foamy
			13.0	0.6	7.03	2000	7.9	cloudy; light brown
			8.0	0.9	7.02	1840	6.5	cloudy; light brown
			7.0	1.1	6.98	1830	6.7	cloudy; light brown
	OW 29-14	16.0	7.0	0.4	6.73	2120	8.0	cloudy; light grey
			10.0	1.1	6.80	2170	8.7	cloudy; light grey
			15.0	2.0	6.83	2200	8.5	cloudy; light grey
			16.0	3.0	6.85	2230	8.7	cloudy; light grey

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Notes:

NM Parameter Not Measured

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL STUDY
PROJECT NUMBER: 192039.00

TABLE NAME: CALCULATION OF SURFACE WATER FLUX
CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES
TABLE NUMBER: B1-3

MEASURED VOLUME *(L)*	ELAPSED TIME *(s)*	ESTIMATED FLUX *(L/s)*
0.25	1.9	0.13
0.25	2.1	0.12
ARITHMETIC MEAN		0.13

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Note:

A graduated beaker was held under a naturally occurring weir-like structure and the time to fill to 250 mL was measured using a stop watch.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER ONTARIO BASED LANDFILL STUDY
PROJECT NUMBER:	192039.00
TABLE NAME:	CALCULATION OF SURFACE WATER FLUX ATLAS SPECIALITY STEELS LANDFILL SITE
TABLE NUMBER:	B1-4

MEASURED VOLUME *(L)*	ELAPSED TIME *(s)*	ESTIMATED FLUX *(L/s)*
10	10.8	0.93
10	9.8	1.02
10	9.0	1.11
10	9.0	1.11
10	9.1	1.10
ARITHMETIC MEAN		1.05

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Note:

A graduated pail was held under the outflow pipe and the time to fill to 10 L was measured using a stop watch.

Flow over the weir was also observed. The flow was approximately equal to the flow through the pipe. However the overflow was not included in the surface water flux calculation.

APPENDIX C

APPENDIX C1

C1 - CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES

- TABLE C1-1: GROUND WATER LOADING CONCENTRATIONS
- TABLE C1-2: SURFACE WATER LOADING CONCENTRATIONS
- TABLE C1-3: CALCULATION OF POTENTIAL LOADINGS TO THE NIAGARA RIVER

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER - ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: GROUND WATER LOADING CONCENTRATIONS CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES
TABLE NUMBER: C1-1

PARAMETER	CONCENTRATION (mg/L)											
	BEDROCK BACKGROUND WELL BG 1-I		OVERBURDEN BACKGROUND WELL BG 1-II		PATHWAY 1 WELL A1-8-1		PATHWAY 2 WELL C1-4-II		PATHWAY 3 WELL C1-5-I		PATHWAY 4 WELL B1-10-II	
INORGANICS												
Copper	0.0020	*	0.0095	T	0.0007	T	0.0120		0.0004	T	0.0140	T
Nickel	0.010	*	0.010	*	0.001	*	0.052		0.005	T	0.010	*
Lead	0.086	T	0.130	T	0.013	T	0.005	*	0.005	*	0.096	T
Zinc	0.6700		0.8900		0.0020	*	0.2100		0.0020	*	0.8300	
Beryllium	0.00280		0.00140	T	0.00020	T	0.00020	T	0.00020	T	0.00420	
Cyanide	0.001	*	0.001	*	0.340		8.800		15.000		1.200	
Cadmium	0.0020	*	0.0020	*	0.0002	*	0.0003	T	0.0006	T	0.0020	*
Chromium	0.012	T	0.029	T	0.007	T	0.012		0.013		0.010	*
Mercury	0.02	*	0.02	*	0.02	*	0.04	T	0.02	*	0.02	*
Antimony	0.003	T	0.004	T	0.002	T	0.009		0.015		0.002	T
Inorganics Total (mg/L)	0.80880		1.09690		0.38610		9.14050		15.06120		2.18820	
ORGANICS												
Phenol	0.0002	*	0.0002	*	0.0036	T	0.0600		0.0630		0.0002	*
Di-n-butylphthalate	0.0027	***	0.0000	**	0.0005	***	0.0000	**	0.0000	**	0.0064	***
Bis-2-ethylhexylphthalate	0.0020	***	0.0020	***	0.0000	**	0.0020	***	0.0000	**	0.0000	**
m-Cresol	0.0002	*	0.0002	*	0.0060		0.0334		0.0011	T	0.0002	*
p-Cresol	0.0002	*	0.0002	*	0.0264		0.0002	*	0.0044		0.0002	*
o-Cresol	0.0002	*	0.0002	*	0.0002	*	0.0002	*	0.0012	****	0.0002	*
Indole	0.0002	*	0.0002	*	0.0002	*	0.0140		0.0002	*	0.0002	*
1,2,4 Trichlorobenzene	0.000002	*	0.000002	*	0.000002	*	0.000002	T	0.000002	T	0.000002	*
Organics Total (mg/L)	0.005702		0.003002		0.036902		0.109802		0.069902		0.007402	

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Notes:

1) Pathway 1 - Bedrock ground water flow to the Queenston-Chippawa Power Canal
Pathway 2 - Overburden ground water flow to the Queenston-Chippawa Power Canal
Pathway 3 - Bedrock ground water flow to the Niagara River through the buried St. Davids Gorge
Pathway 4 - Overburden ground water flow to the Niagara River

2) Concentrations not detected within a monitor but detected at another monitor are presented as the analytical detection limit.

3) Total concentrations are presented to reflect lowest concentration detected.

4) Shaded parameters are NRTC parameters of concern.

* Analytical Detection Limit
** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.
*** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.
**** Concentration detected unreliable, indeterminate interference.
T A measurable trace amount was detected in the sample.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039.00
TABLE NAME:	SURFACE WATER LOADINGS CONCENTRATIONS CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES
TABLE NUMBER:	C1-2

PARAMETER	CONCENTRATION *(mg/L)*	
	PATHWAY 5 STATION SW16	
INORGANICS		
Copper	0.0059	
Nickel	0.025	
Lead	0.014	T
Zinc	0.0024	T
Beryllium	0.00030	
Cyanide	1.200	
Cadmium	0.0003	T
Chromium	0.021	
Mercury	0.03	T
Antimony	0.010	
Inorganics Total (mg/L)	1.30890	
ORGANICS		
Phenol	0.1900	
Di-n-butylphthalate	0.0000	**
Bis-2-ethylhexylphthalate	0.0000	**
m-Cresol	0.0036	T
p-Cresol	0.0115	
o-Cresol	0.0006	***
Hexachloroethane	0.000010	T
Organics Total (mg/L)	0.205710	

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Notes:

1) Pathway 5 – Surface water flow to the Niagara River from a spring at the base of the Whirlpool Gorge.

2) Concentrations not detected within a monitor but detected at another monitor are presented as the analytical detection limit.

3) Total concentrations are presented to reflect lowest concentration detected.

4) Shaded parameters are NRTC parameters of concern.

* Analytical Detection Limit

** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.

*** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.

T A measurable trace amount was detected in the sample.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039
TABLE NAME:	CALCULATION OF POTENTIAL LOADINGS TO THE NIAGARA RIVER CYANAMID CANADA INC. NIAGARA FALLS LANDFILL SITES
TABLE NUMBER:	C1-3

MIGRATION PATHWAY 1:

Bedrock Ground Water Flow to the Queenston Chippawa Power Canal

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (0.3861mg/L*2688000 L/day)/10E6mg/kg+(0.0369mg/L*2688000L/day)/10E6mg/kg
= 0.1038 kg/day + 0.0099 kg/day
= 0.1137 kg/day

MIGRATION PATHWAY 2:

Overburden Ground Water Flow to the Queenston Chippawa Power Canal

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (9.1405 mg/L*557384L/day)/10E6 mg/kg+(0.1098mg/L*557384L/day)/10E6mg/kg
= 5.0948 kg/day + 0.0612 kg/day
= 5.1560 kg/day

MIGRATION PATHWAY 3:

Bedrock Ground Water Flow to the buried St. Davids Gorge

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (15.0612mg/L*67200L/day)/10E6mg/kg+(0.06994mg/L*67200L/day)/10E6mg/kg
= 1.0121 kg/day + 0.0047 kg/day
= 1.0168 kg/day

MIGRATION PATHWAY 4:

Overburden Ground Water Flow to the Niagara River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (2.1882mg/L*52255L/day)/10E6mg/kg+(0.0074mg/L*52255L/day)/10E6mg/kg
= 0.1143 kg/day + 0.0004 kg/day
= 0.1147 kg/day

MIGRATION PATHWAY 5:

Surface Water Flow to the Niagara River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (1.3089mg/L*10800L/day)/10E6mg/kg+(0.2057mg/L*10800L/day)/10E6mg/kg
= 0.0141 kg/day + 0.0022 kg/day
= 0.0164 kg/day

TOTAL POTENTIAL LOADING TO THE NIAGARA RIVER

Ltotal = Lground water + Lsurface water

Ltotal = L1 + L2 + L3 + L4 +L5
= 0.1137 kg/day + 5.156 kg/day + 1.0168 kg/day + 0.1147 kg/day + 0.0164 kg/day
= 6.4176 kg/day

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APPENDIX C2

C2 - CYANAMID CANADA INC. WELLAND LANDFILL SITE

- **TABLE C2-1: GROUND WATER LOADING CONCENTRATIONS**
- **TABLE C2-2: SURFACE WATER LOADING CONCENTRATIONS**
- **TABLE C2-3: CALCULATION OF POTENTIAL LOADINGS TO THE WELLAND RIVER**
- **TABLE C2-4: CALCULATION OF WORST CASE LOADINGS TO THE WELLAND RIVER**

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: GROUND WATER LOADING CONCENTRATIONS CYANAMID CANADA INC. WELLAND LANDFILL SITE
TABLE NUMBER: C2-1

PARAMETER	CONCENTRATION (mg/L)		
	BEDROCK PATHWAY WELL 5-I	OVERBURDEN PATHWAY WELL 5-IV	REFUSE WELL 23-I
INORGANICS			
Copper	0.0240	0.0170 T	0.0040 *
Lead	0.084 T	0.052 T	0.120 T
Zinc	1.7000	1.1000	2.1000
Beryllium	0.00280	0.00080 T	0.00280 T
Cyanide	0.001 *	0.001 *	215.470
Chromium	0.016 T	0.022 T	0.021 T
Antimony	0.002 T	0.004 T	0.011
Inorganics Total (mg/L)	1.82980	1.19680	217.72880
ORGANICS			
Phenol	0.0002 *	0.0002 *	0.0690
Di-n-butylphthalate	0.0000 **	0.0022 ***	0.0290 ***
Bis-2-ethylhexylphthalate	0.0000 **	0.0000 **	0.0210 ***
Chloroform	0.0000 **	0.0000 **	0.0180 ***
Toluene	0.0020 *	0.0004 T	0.0200 *
m-Cresol	0.0002 *	0.0002 *	0.0032
Indole	0.0002 *	0.0002 *	0.0150
Pentachlorobenzene	0.000001 *	0.000009 T	0.000001 *
Hexachloroethane	0.000001 *	0.000003 T	0.000001 *
1,2,4 Trichlorobenzene	0.000007 T	0.000003	0.000002 *
Hexachlorobutadiene	0.000001 *	0.000006 T	0.000001 *
1,2,3 Trichlorobenzene	0.000005 *	0.000001 T	0.000001 *
2,3,6 Trichlorotoluene	0.000001 *	0.000003 T	0.000001 *
1,2,3,5 Tetrachlorobenzene	0.000001 *	0.000015	0.000001 *
Hexachlorobenzene	0.000001 *	0.000005 T	0.000001 *
Heptachlor	0.000001 *	0.000010 T	0.000001 *
Organic Total (mg/L)	0.002619	0.003255	0.175210

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Notes:

1) Concentrations not detected within a monitor but detected at another monitor are presented as the analytical detection limit.

2) Total concentrations are presented to reflect lowest concentration detected.

3) Shaded parameters are NRTC parameters of concern.

* Analytical Detection Limit
** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.
*** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.
T A measurable trace amount was detected in the sample.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: SURFACE WATER LOADINGS CONCENTRATIONS CYANAMID CANADA INC. WELLAND LANDFILL SITE

TABLE NUMBER: C2-2

PARAMETER	CONCENTRATION (mg/L) UPSTREAM STATION C1		CONCENTRATION (mg/L) DOWNSTREAM STATION C9		ADJUSTED DOWNSTREAM CONCENTRATION (mg/L)
INORGANICS					
Copper	0.0028		0.0042		0.0014
Lead	0.013	T	0.010	T	0.000
Zinc	0.0020	*	0.0036	T	0.0016
Silver	0.0024	T	0.0005	*	0.0000
Beryllium	0.00010	T	0.00040		0.00030
Cyanide	0.014		0.022		0.008
Chromium	0.003	T	0.003	T	0.000
Inorganic Total (mg/L)	0.0373		0.0437		0.0113
ORGANICS					
Di-n-butylphthalate	0.0051	***	0.0054	***	0.0003
Bis-2-ethylhexylphthalate	0.0000	**	0.0010	***	0.0010
Chloroform	0.0000	*	0.0020	T***	0.0020
Toluene	0.0004	T	0.0020	*	0.0016
Chlorobenzene	0.0002	*	0.0200		0.0198
Organic Total (mg/L)	0.0057		0.0304		0.0247

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Notes:

1) Concentrations not detected within a monitor but detected at another monitor are presented as the analytical detection limit.

2) Total concentrations are presented to reflect lowest concentration detected.

3) Downstream concentration has been adjusted by the upstream concentration.

4) Shaded parameters are NRTC parameters of concern.

* Analytical Detection Limit

** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.

*** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.

T A measurable trace amount was detected in the sample.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039
TABLE NAME:	CALCULATION OF POTENTIAL LOADINGS TO THE WELLAND RIVER CYANAMID CANADA INC. WELLAND LANDFILL SITE
TABLE NUMBER:	C2–3

MIGRATION PATHWAY 1:

Bedrock Ground Water Flow to the Welland River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (1.8298mg/L*2601L/day)/10E6mg/kg+(0.0026mg/L*2601L/day)/10E6mg/kg
= 0.0048 kg/day + 0.0000 kg/day
= 0.0048 kg/day

MIGRATION PATHWAY 2:

Overburden Ground Water Flow to the Welland River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (1.1968mg/L*55L/day)/10E6 mg/kg+(0.0032mg/L*55L/day)/10E6mg/kg
= 0.0001 kg/day + 0.0000 kg/day
= 0.0001 kg/day

MIGRATION PATHWAY 3:

Surface Water Flow in Thompson Creek

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (0.0114mg/L*10080000L/day)/10E6mg/kg+(0.0247mg/L*10080000L/day)/10E6mg/kg
= 0.1139 kg/day + 0.2490 kg/day
= 0.3629 kg/day

TOTAL POTENTIAL LOADING TO THE NIAGARA RIVER

Ltotal = Lground water + Lsurface water

Ltotal = L1 + L2 + L3
= 0.0048 kg/day + 0.0001 kg/day + 0.3629 kg/day
= 0.3677 kg/day

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PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039
TABLE NAME: CALCULATION OF WORST CASE LOADINGS TO THE WELLAND RIVER CYANAMID CANADA INC. WELLAND LANDFILL SITE
TABLE NUMBER: C2-4

MIGRATION PATHWAY 1:

Bedrock Ground Water Flow to the Welland River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (217.7288mg/L*2601L/day)/10E6mg/kg+(0.1752mg/L*2601L/day)/10E6mg/kg
= 0.5663 kg/day + 0.0005 kg/day
= 0.5663 kg/day

MIGRATION PATHWAY 2:

Overburden Ground Water Flow to the Welland River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (217.7288mg/L*55L/day)/10E6 mg/kg+(0.1752mg/L*55L/day)/10E6mg/kg
= 0.0120 kg/day + 0.0000 kg/day
= 0.0120 kg/day

MIGRATION PATHWAY 3:

Surface Water Flow in Thompson Creek

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (0.0247mg/L*10080000L/day)/10E6mg/kg+(0.0247mg/L*10080000L/day)/10E6mg/kg
= 0.1139 kg/day + 0.2490 kg/day
= 0.3629 kg/day

TOTAL POTENTIAL LOADING TO THE NIAGARA RIVER

Ltotal = Lground water + Lsurface water

Ltotal = L1 + L2 + L3
= 0.5668 kg/day + 0.0120 kg/day + 0.3629 kg/day
= 0.9416 kg/day

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APPENDIX C3

C3 - ATLAS SPECIALTY STEELS LANDFILL SITE

- TABLE C3-1: GROUND WATER LOADING CONCENTRATIONS
- TABLE C3-2: SURFACE WATER LOADING CONCENTRATIONS
- TABLE C3-3: CALCULATION OF POTENTIAL LOADINGS TO THE WELLAND RIVER
- TABLE C3-4: NON PRIORITY POLLUTANT GROUND WATER CONCENTRATIONS
- TABLE C3-5: NON PRIORITY POLLUTANT SURFACE WATER CONCENTRATIONS
- TABLE C3-6: CALCULATION OF NON PRIORITY LOADINGS TO THE WELLAND RIVER

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: GROUND WATER LOADING CONCENTRATIONS ATLAS SPECIALITY STEELS LANDFILL SITE

TABLE NUMBER: C3–1

PARAMETER	CONCENTRATION (mg/L)			MEAN CONCENTRATION (mg/L)
	DOWNGRADIENT WELL AS12	DOWNGRADIENT WELL AS13	DOWNGRADIENT WELL AS14	
INORGANICS				
Copper	0.0062	0.0260	0.0058	0.0127
Nickel	1.400	0.013 T	0.008 T	0.474
Lead	0.032	0.062	0.036	0.043
Zinc	0.0020 *	0.6800	0.0020 *	0.228
Silver	0.0012 T	0.0005 *	0.0025 T	0.0014
Beryllium	0.00020 T	0.00280	0.00020 T	0.00107
Cadmium	0.0007 T	0.0002 *	0.0002 *	0.0004
Chromium	0.001 T	0.013 T	0.001 *	0.005
Antimony	0.006	NR	0.003 T	0.003
Inorganic Total (mg/L)	1.44930	0.79750	0.05870	0.76850
ORGANICS				
Phenol	0.0326	0.0002 *	0.0002 *	0.0110
Bis–2–ethylhexyl phthalate	0.0000 **	0.0010	0.0000 **	0.0003
Di–n–butyl phthalate	0.0000 **	0.0017	0.0011 ***	0.0009
Chloroform	0.0000 **	0.0002 *	0.0020 ***	0.0007
Toluene	0.0002 *	0.0006 T	0.0002 *	0.0003
m–Cresol	0.0011 ****	0.0002 *	0.0002 *	0.0005
Indole	0.0068	0.0002 *	0.0002 *	0.0024
p–Cresol	0.0008 T	0.0002 *	0.0002 *	0.0004
Trichloroethylene	0.0150	0.0010	0.0010 *	0.0057
1,2,4 Trichlorobenezene	0.000002 *	0.000002 *	0.000003 T	0.000002
Pentachlorobenezene	0.000001 *	0.000002 T	0.000001 T	0.000001
Hexachlorobenzene	0.000001 *	0.000007 T	0.000001 *	0.000003
Endosulfan I	0.000002 *	0.000002 *	0.000006 T	0.000003
Organic Total (mg/L)	0.056506	0.005313	0.005111	0.022310

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Notes:

1) Total concentrations are presented to reflect the lowest concentration detected.
2) Metal mean concentration represents the arithmetic mean of concentrations detected in samples from three monitoring wells while the organic mean concentration represents the arithmetic mean of concentrations detected in two monitoring wells.
3) Shaded parameters are NRTC parameters of concern.

* Analytical Detection Limit

** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.

*** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.

**** Concentration detected unreliable, indeterminate interference.

T A measurable trace amount was detected in the sample.

NR Not reported

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039
TABLE NAME: SURFACE WATER LOADING CONCENTRATIONS ATLAS SPECIALITY STEELS LANDFILL SITE
TABLE NUMBER: C3-2

PARAMETER	CONCENTRATION (mg/L)				MEAN CONCENTRATION (mg/L)
	OUTFLOW WEIR STATION SS3		OUTFLOW WEIR (DUPLICATE)		
INORGANICS					
Copper	0.0220		0.0210		0.0215
Nickel	0.029		0.029		0.029
Lead	0.033		0.020		0.027
Beryllium	0.00030		0.00030		0.00030
Cyanide	0.150		0.054		0.102
Chromium	0.310		0.290		0.300
Mercury	0.02	*	0.03	T	0.03
Antimony	0.003	T	0.002	T	0.0025
Inorganic Total (mg/L)	0.56730		0.44630		0.50680
ORGANICS					
Phenol	0.0131		0.0144		0.0138
Bis-2-ethylhexyl phthalate	0.0140	***	0.0000	**	0.0070
Di-n-butyl phthalate	0.0000	**	0.0000	**	0.0000
1,1 Dichloroethylene	0.0010	T	0.0020	T	0.0015
Chloroform	0.0004	T	0.0004	T	0.0004
Trichloroethylene	0.0500		0.0540		0.0520
Tetrachloroethylene	0.0005	*	0.0005	T	0.0005
Toluene	0.0010	T	0.0010	T	0.0010
m-Cresol	0.0013	T	0.0015	T	0.0014
Indole	0.0008	T	0.0002	*	0.0005
p-Cresol	0.0008	T	0.0009	T	0.0009
1-Methylnapthalene	0.0006	T	0.0007	T	0.0007
2-Methylnapthalene	0.0006	****	0.0007	****	0.0007
Hexachloroethane	0.000002	T	0.000002	T	0.000002
1,3,5 Trichlorobenzene	0.000006	T	0.000005	T	0.000006
1,2,4 Trichlorobenezene	0.000040		0.000034		0.000037
1,2,3 Trichlorobenzene	0.000030		0.000023		0.000027
1,2,3,5 Tetrachlorobenezene	0.000004	T	0.000003	T	0.000004
1,2,4,5 Tetrachlorobenezene	0.000009	T	0.000004	T	0.000007
1,2,3,4 Tetrachlorobenezene	0.000018	T	0.000015	T	0.000017
Pentachlorobenezene	0.000001	T	0.000002	T	0.000002
Hexachlorobenezene	0.000001	T	0.000001	*	0.000001
Organic Total (mg/L)	0.084211		0.076389		0.080300

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Notes:

1) Total concentrations are presented to reflect the lowest concentration detected.
2) Shaded parameters are NRTC parameters of concern.
* Analytical Detection Limit
** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.
*** Concentration have been adjusted to reflect the concentration detected in the laboratory blank.
**** Concentration detected unreliable, indeterminate interference.
T A measurable trace amount was detected in the sample.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039
TABLE NAME:	CALCULATION OF POTENTIAL LOADINGS TO THE WELLAND RIVER ATLAS SPECIALTY STEELS LANDFILL SITE
TABLE NUMBER:	C3–3

MIGRATION PATHWAY 1:

Overburden Ground Water Flow to the Welland River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (0.76850mg/L*1067L/day)/10E6 mg/kg+(0.0223mg/L*1067Lday)/10E6mg/kg
= 0.0008 kg/day + 0.0000 kg/day
= 0.0008 kg/day

MIGRATION PATHWAY 2:

Surface Water Flow

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (0.5068mg/L*91022L/day)/10E6mg/kg+(0.0798mg/L*91022L/day)/10E6mg/kg
= 0.0461 kg/day + 0.0073 kg/day
= 0.0534 kg/day

TOTAL POTENTIAL LOADING TO THE NIAGARA RIVER

Ltotal = Lground water + Lsurface water

Ltotal = L1 + L2
= 0.0008 kg/day + 0.0536 kg/day
= 0.0543 kg/day

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PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039

TABLE NAME: NON PRIORITY POLLUTANT GROUND WATER LOADING CONCENTRATIONS ATLAS SPECIALITY STEELS LANDFILL SITE

TABLE NUMBER: C3–4

PARAMETER	CONCENTRATION (mg/L)			MEAN CONCENTRATION (mg/L)
	AS12	AS13	AS14	
INORGANICS				
Copper	0.0062	0.0260	0.0058	0.0127
Nickel	1.400	0.013	0.008	0.474
Lead	0.032	0.062	0.036	0.043
Iron	2.500	4.800	5.600	4.300
Manganese	9.8000	9.1000	12.0000	10.3000
Silver	0.0012	0.0050	0.0025	0.0029
Aluminum	2.000	0.600	2.100	1.567
Barium	0.0300	0.5300	0.0280	0.1960
Beryllium	0.00020	0.00280	0.00020	0.00107
Cadmium	0.0007	0.0020	0.0002	0.0010
Cobalt	0.0260	0.0530	0.0033	0.0274
Molybdenum	0.0063	0.0180	0.1800	0.0681
Antimony	0.006	0.007	0.003	0.005
Strontium	6.20000	4.20000	4.10000	4.83333
Inorganic Total (mg/L)	22.0086	19.4188	24.0670	21.8315
ORGANICS				
Phenol	0.0326	0.0002	0.0002	0.0164
Bis–2–ethylhexyl phthalate	0.0000	0.0010	0.0000	0.0000
Di–n–butyl phthalate	0.0000	0.0017	0.0011	0.0006
Chloroform	0.0000	0.0002	0.0020	0.0010
Toluene	0.0002	0.0006	0.0002	0.0002
m–Cresol	0.0011	0.0002	0.0002	0.0007
Indole	0.0068	0.0002	0.0002	0.0035
p–Cresol	0.0008	0.0002	0.0002	0.0005
Trichloroethylene	0.015	0.0010	0.001	0.0080
1,2,4 Trichlorobenezene	0.000002	0.000002	0.000003	0.000003
Pentachlorobenezene	0.000001	0.000002	0.000001	0.000001
Hexachlorobenzene	0.000001	0.000007	0.000001	0.000001
Endosulfan I	0.000002	0.000002	0.000006	0.000004
Organic Total (mg/L)	0.056506	0.005313	0.005111	0.030809

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Notes:

1) Total concentrations are presented to reflect the lowest concentration detected.
2) Shaded parameters are NRTC parameters of concern.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: NON PRIORITY POLLUTANT SURFACE WATER LOADING CONCENTRATIONS ATLAS SPECIALITY STEELS LANDFILL SITE
TABLE NUMBER: C3-5

PARAMETER	CONCENTRATION (mg/L)		MEAN CONCENTRATION (mg/L)
	OUTFLOW WEIR	OUTFLOW WEIR (DUPLICATE)	
INORGANICS			
Copper	0.0220	0.0210	0.0215
Nickel	0.029	0.029	0.029
Lead	0.033	0.020	0.027
Iron	0.016	0.017	0.017
Manganese	0.0087	0.0120	0.0104
Aluminum	0.400	0.340	0.370
Barium	0.5100	0.4900	0.5000
Beryllium	0.00030	0.00030	0.00030
Cyanide	0.150	0.054	0.102
Cobalt	0.0030	0.0008	0.0019
Chromium	0.310	0.290	0.300
Mercury	0.02	0.03	0.03
Molybdenum	3.2000	3.1000	3.1500
Antimony	0.003	0.002	0.003
Strontium	2.30000	2.20000	2.25000
Inorganic Total (mg/L)	7.00500	6.60610	6.80555
ORGANICS			
Phenol	0.0131	0.0144	0.0138
Bis-2-ethylhexyl phthalate	0.0140	0.0000	0.0070
Di-n-butyl phthalate	0.0000	0.0000	0.0000
1,1 Dichloroethylene	0.0010	0.0020	0.0015
Chloroform	0.0004	0.0004	0.0004
Trichloroethylene	0.0500	0.0540	0.0520
Tetrachloroethylene	0.0005	0.0005	0.0005
Toluene	0.0010	0.0010	0.0010
m-Cresol	0.0013	0.0015	0.0014
Indole	0.0008	0.0002	0.0005
p-Cresol	0.0008	0.0009	0.0009
1-Methylnapthalene	0.0006	0.0007	0.0007
2-Methylnapthalene	0.0006	0.0007	0.0007
Hexachloroethane	0.000002	0.000002	0.000002
1,3,5 Trichlorobenzene	0.000006	0.000005	0.000006
1,2,4 Trichlorobenezene	0.000040	0.000034	0.000037
1,2,3 Trichlorobenezene	0.000030	0.000023	0.000027
1,2,3,5 Tetrachlorobenezene	0.000004	0.000003	0.000004
1,2,4,5 Tetrachlorobenezene	0.000009	0.000004	0.000007
1,2,3,4 Tetrachlorobenezene	0.000018	0.000015	0.000016
Pentachlorobenezene	0.000001	0.000002	0.000002
Hexachlorobenezene	0.000001	0.000001	0.000001
Organic Total (mg/L)	0.084211	0.076389	0.080300

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Notes:

Notes: 1) Total concentrations are presented to reflect the lowest concentration detected.
2) Shaded parameters are NRTC parameters of concern.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039
TABLE NAME:	CALCULATION OF NON PRIORITY LOADINGS TO THE WELLAND RIVER ATLAS SPECIALTY STEELS LANDFILL SITE
TABLE NUMBER:	C3–6

MIGRATION PATHWAY 1:

Overburden Ground Water Flow to the Welland River

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (21.8315mg/L*1067L/day)/10E6 mg/kg+(0.0308 mg/L*1067L/day)/10E6mg/kg
= 0.0233 kg/day + 0.0000 kg/day
= 0.0233 kg/day

MIGRATION PATHWAY 2:

Surface Water Flow

L = (Cmetal * Q)/A + (Corganic * Q)/A

L = (6.8056mg/L*91022L/day)/10E6mg/kg+(0.0798mg/L*91022L/day)/10E6mg/kg
= 0.6195 kg/day + 0.0073 kg/day
= 0.6267 kg/day

TOTAL POTENTIAL LOADING TO THE NIAGARA RIVER

Ltotal = Lground water + Lsurface water

Ltotal = L1 + L2
= 0.0233 kg/day + 0.6267 kg/day
= 0.6500 kg/day

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APPENDIX C4

C4 - BRIDGE STREET MUNICIPAL LANDFILL SITE

- TABLE C4-1: GROUND WATER LOADING CONCENTRATIONS
- TABLE C4-2: SURFACE WATER LOADING CONCENTRATIONS
- TABLE C4-3: CALCULATION OF POTENTIAL LOADINGS TO THE NIAGARA RIVER
- TABLE C4-4: GROUND WATER LOADING CONCENTRATIONS WITHOUT ZINC
- TABLE C4-5: SURFACE WATER LOADING CONCENTRATIONS WITHOUT ZINC

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: GROUND WATER LOADING CONCENTRATIONS BRIDGE STREET MUNICIPAL LANDFILL SITE

TABLE NUMBER: C4-1

PARAMETER	CONCENTRATION (mg/L)					
	DOWNGRADIENT BEDROCK WELL MW 29-14		DOWNGRADIENT OVERBURDEN WELL MW 23-5		REFUSE WELL 17-8	
INORGANICS						
Copper	0.0140	T	0.0047	T	0.0120	T
Nickel	0.017	T	0.010	*	0.010	*
Lead	0.240	T	0.050	*	0.120	T
Zinc	0.7200		0.7800		0.7300	
Beryllium	0.00140	T	0.00280		0.00280	T
Chromium	0.02	T	0.012	T	0.016	T
Antimony	0.008		0.012		0.010	T
Inorganic Total (mg/L)	1.02040		0.87150		0.90080	
ORGANICS						
Di-n-butylphthalate	0.0023	***	0.0000	***	0.0026	***
Bis-2-ethylhexylphthalate	0.0040	T***	0.0050	***	0.0040	***
Dichloromethane	0.0005	*	0.0005	*	0.0500	
1,1 Dichloroethane	0.0005	*	0.0005	*	0.0150	
Chloroform	0.0002	*	0.0002	T	0.0002	T
Benzene	0.0002	*	0.0002	*	0.0010	T
Trichloroethylene	0.0010	*	0.0010	T	0.0010	*
Toluene	0.0004		0.0006	T	0.0006	T
Chloroethane	0.0010	*	0.0010	*	0.0070	T
Chloromethane	0.0010	*	0.0010	*	0.0020	T
Hexachloroethane	0.000001	T	0.000005	T	0.000001	*
1,2,4 Trichlorobenzene	0.000002	*	0.000002	*	0.000003	T
Pentachlorobenzene	0.000004	T	0.000001	*	0.000001	T
Hexachlorobenzene	0.000001	*	0.000001	*	0.000007	T
G-Chlordane	0.000002	*	0.000002	*	0.000016	T
Organic Total (mg/L)	0.011110		0.010011		0.083428	

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Notes:

1) Total concentrations are presented to reflect the lowest concentration detected.

* Analytical Detection Limit

** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.

*** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.

T A measurable trace amount was detected in the sample.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039.00
TABLE NAME:	SURFACE WATER LOADING CONCENTRATIONS BRIDGE STREET MUNICIPAL LANDFILL SITE
TABLE NUMBER:	C4-2

PARAMETER	CONCENTRATION *(mg/L)* SUFRACE WATER STATION S4a	
INORGANICS		
Zinc	0.610	
Beryllium	0.00140	T
Chromium	0.017	T
Inorganic Total (mg/L)	0.62840	
ORGANICS		
Di-n-butylphthalate	0.0052	**
Bis-2-ethylhexylphthalate	0.0020	**
Organic Total (mg/L)	0.0072	

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Notes:

1) Total concentrations are presented to reflect the lowest concentration detected.

2) Shaded parameters are NRTC parameters of concern.

* Analytical Detection Limit
** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.
T A measurable trace amount was detected in the sample.

PROJECT NAME:	CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER:	192039
TABLE NAME:	CALCULATION OF POTENTIAL LOADINGS TO THE NIAGARA RIVER BRIDGE STREET MUNICIPAL LANDFILL SITE
TABLE NUMBER:	C4-3

MIGRATION PATHWAY 1:

Bedrock Ground Water Flow to the Niagara River	L	=	(Cmetal * Q)/A + (Corganic * Q)/A
	L	=	(1.0204mg/L*4665600L/day)/10E6mg/kg + (0.0111mg/L*4665600L/day)/10E6mg/kg
		=	4.7608 kg/day + 0.0518 kg/day
		=	4.8126 kg/day

MIGRATION PATHWAY 2:

Overburden Ground Water Flow to the Niagara River	L	=	(Cmetal * Q)/A + (Corganic * Q)/A
	L	=	(0.8715mg/L*5702L/day)/10E6 mg/kg + (0.0100mg/L*5702L/day)/10E6 mg/kg
		=	0.0050 kg/day + 0.0001 kg/day
		=	0.0050 kg/day

MIGRATION PATHWAY 3:

Surface Water Flow in Miller Creek	L	=	(Cmetal * Q)/A + (Corganic * Q)/A
	L	=	(0.6284mg/L*1440L/day)/10E6mg/kg + (0.0072 mg/L*1440L/day)/10E6mg/kg
		=	0.0009 kg/day + 0.0000 kg/day
		=	0.0009 kg/day

TOTAL POTENTIAL LOADING TO THE NIAGARA RIVER

Ltotal	=	Lground water + Lsurface water
Ltotal	=	L1 + L2 + L3
	=	4.8126 kg/day + 0.0050 kg/day + 0.0009 kg/day
	=	4.8186 kg/day

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PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: GROUND WATER LOADING CONCENTRATIONS WITHOUT ZINC BRIDGE STREET MUNICIPAL LANDFILL SITE
TABLE NUMBER: C4-4

PARAMETER	CONCENTRATION (mg/L)					
	DOWNGRADIENT BEDROCK WELL MW 29-14		DOWNGRADIENT OVERBURDEN WELL MW 23-5		REFUSE WELL 17-8	
INORGANICS						
Copper	0.0140	T	0.0047	T	0.0120	T
Nickel	0.017	T	0.010	*	0.010	*
Lead	0.240	T	0.050	*	0.120	T
Beryllium	0.00140	T	0.00280		0.00280	T
Chromium	0.02	T	0.012	T	0.016	T
Antimony	0.008		0.012		0.010	T
Inorganic Total (mg/L)	0.30040		0.09150		0.17080	
ORGANICS						
Di-n-butylphthalate	0.0023	***	0.0000	***	0.0026	***
Bis-2-ethylhexylphthalate	0.0040	T***	0.0050	***	0.0040	***
Dichloromethane	0.0005	*	0.0005	*	0.0500	
1,1 Dichloroethane	0.0005	*	0.0005	*	0.0150	
Chloroform	0.0002	*	0.0002	T	0.0002	T
Benzene	0.0002	*	0.0002	*	0.0010	T
Trichloroethylene	0.0010	*	0.0010	T	0.0010	*
Toluene	0.0004		0.0006	T	0.0006	T
Chloroethane	0.0010	*	0.0010	*	0.0070	T
Chloromethane	0.0010	*	0.0010	*	0.0020	T
Hexachloroethane	0.000001	T	0.000005	T	0.000001	*
1,2,4 Trichlorobenzene	0.000002	*	0.000002	*	0.000003	T
Pentachlorobenzene	0.000004	T	0.000001	*	0.000001	T
Hexachlorobenzene	0.000001	*	0.000001	*	0.000007	T
G-Chlordane	0.000002	*	0.000002	*	0.000016	T
Organic Total (mg/L)	0.011110		0.010011		0.083428	

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Notes:

1) Total concentrations are presented to reflect the lowest concentration detected.

* Analytical Detection Limit

** Concentration detected in laboratory blank exceeded the concentration detected in the sample. A concentration of 0 mg/L has been assumed.

*** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.

T A measurable trace amount was detected in the sample.

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER – ONTARIO BASED LANDFILL SITES
PROJECT NUMBER: 192039.00
TABLE NAME: SURFACE WATER LOADING CONCENTRATIONS WITHOUT ZINC BRIDGE STREET MUNICIPAL LANDFILL SITE
TABLE NUMBER: C4-5

PARAMETER	CONCENTRATION *(mg/L)* SUFRACE WATER STATION S4a	
INORGANICS		
Beryllium	0.00140	T
Chromium	0.017	T
Inorganic Total (mg/L)	0.01840	
ORGANICS		
Di-n-butylphthalate	0.0052	**
Bis-2-ethylhexylphthalate	0.0020	**
Organic Total (mg/L)	0.0072	

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Notes:

1) Total concentrations are presented to reflect the lowest concentration detected.

2) Shaded parameters are NRTC parameters of concern.

* Analytical Detection Limit
** Concentration has been adjusted to reflect the concentration detected in the laboratory blank.
T A measurable trace amount was detected in the sample.

APPENDIX D

o TABLE D1-1: SUMMARY OF STATUS OF 13 ONTARIO BASED LANDFILL SITES

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: SUMMARY OF STATUS OF 13 CANADIAN BASED LANDFILL SITES

TABLE NUMBER: D1-1

SITE NAME	LOCATION	OPERATION	WASTE TYPE	CURRENT STATUS			
				MONITORING NETWORK	SAMPLING FREQUENCY	PARAMETERS ANALYSED	ADDITIONAL COMMENTS
CN Rail Lands Victoria Avenue Landfill Site	West of Victoria Avenue and River Road, City of Niagara Falls	1960's - 1981	Wastes include: scrap metals, wood, paper, lube pads.	Existing monitoring network consists of: o one surface water sampling station o one overburden monitoring well	Surface water sampled annually by the MOE since 1982; Ground water sampling has been infrequent.	Surface water analysis have included: general chemistry, metals, some organics; Ground water analysis have included: general chemistry, some metals, and PCB/Pesticides scan.	Installation of 2 monitoring wells and sampling of leachate, ground water and surface water are proposed for 1993. Proposed chemical analysis includes: general chemistry, metals, volatile organics, semi-volatile organics, and PCBs and Pesticides.
Norton Company Landfill Sites (2 sites)	Ort Road and Pell Road Niagara Falls	unknown - present	Industrial wastes including: aluminum oxide silicone carbide	Upstream and Downstream samples have historically been collected from Pell Creek	Surface water sampling has been infrequent	Samples have been analysed for chloride, alkalinity, conductivity pH, hardness	Chloride and conductivity concentrations have been noted to decrease downstream of the site relative to upstream; the decrease is attributed to dilution by process water that discharges to Pell Creek. Analyses suggest that the site has impact on surface water; Remedial actions have been proposed but their status is unknown.
Canadian Carborundum Disposal Areas	Lot 190 City of Niagara Falls	pre-1980 - present	Wastes include: construction rubble, brick, stone, bauxite sweepings alumina sludge	Surface water has historically been sampled along perimeter ditches	Surface water sampling has been infrequent	Field analysis of three surface water water samples has include alkalinity, conductivity pH, hardness	Two waste areas are identified on the property; Wastes have generally been piled on the ground surface or concrete pads; Limited field analyses suggest that the site has little impact on surface water

PROJECT NAME: CONTAMINANT LOADINGS TO THE NIAGARA RIVER
ONTARIO BASED LANDFILL SITES

PROJECT NUMBER: 192039.00

TABLE NAME: SUMMARY OF STATUS OF 13 CANADIAN BASED LANDFILL SITES

TABLE NUMBER: D1-1

SITE NAME	LOCATION	OPERATION	WASTE TYPE	CURRENT STATUS			
				MONITORING NETWORK	SAMPLING FREQUENCY	PARAMETERS ANALYSED	ADDITIONAL COMMENTS
Niagara Metals Disposal Areas	Lot 189 City of Niagara Falls	mid 1950s – 1984	Industrial waste including: brick, iron oxide, scrap metal, coke	Existing monitoring network consists of: o one bedrock well o one surface water station	One field sampling event has been completed	Field analysis includes: alkalinity, conductivity, pH, hardness, sulphates, chromium (VI)	Limited field analyses suggest that the site has little impact on bedrock ground water and surface water.
Fleet Landfill Fort Erie	Lot 4, Concession VII City of Welland	1930 – 1971	Industrial waste associated with Fleet Industries Fort Erie operation including paint thinners and wood waste	Surface water sampling has been conducted along Frenchmens Creek and a number of perimeter ditches on the landfill and plant property	Sampling is conducted infrequently as part of ongoing remediation investigations and feasibility studies for the plant property	Sample analysis includes: general chemistry and metals. Elevated phenolics and some metals have been detected in the past.	Installation of monitoring wells is proposed for the landfill site as part of remedial works at the Fleet Industries properties. Visible scrap metal was removed from the landfill property in 1987 as part of the revegetation/rehabilitation program.
Stelco Welland Tube Works Disposal Areas	Lot 19 Concession VII City of Welland	1973 – 1979	Dry industrial wastes including: scrap steel, concrete rubble, welding flux	No data available on existence of ground water monitoring network; Surface water sampling includes locations upstream and downstream of site.	Surface water sampled infrequently at site; Data available for one sampling event upstream and downstream of the site.	Surface water samples were analysed for: alkalinity, conductivity, pH and hardness; Parameters were slightly elevated upstream of the site relative to downstream.	

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SITE NAME	LOCATION	OPERATION	WASTE TYPE	CURRENT STATUS			
				MONITORING NETWORK	SAMPLING FREQUENCY	PARAMETERS ANALYSED	ADDITIONAL COMMENTS
Stelco Page Hersey Landfill	No Data Available	No Data Available	No Data Available	No Data Available	No Data Available	No Data Available	MOEE Welland Office reports no record of landfill site; Landfill site possibly corresponds to the Union Carbide Landfill Site located on Townline Road in Welland.
Welland Iron & Brass Landfill	Lot 18, Concession VII City of Welland	1973 – 1976 1979 – late 1980s	Waste materials include: foundry sand, ash, brick, some slag, clinker waste	Surface water has historically been collected from standing water adjacent to the site and from a perimeter ditch.	Data is available for one sampling event	Field analysis of surface water samples and ground water samples include: chloride, alkalinity, conductivity, pH, hardness, sulphates, chromium	Limited field analyses suggest that the site has little impact on surface water; Welland Iron & Brass is no longer in business; Future plans for the landfill site are not known.
Welland Municipal Landfill Site (also known as Humberstone Landfill Site)	Feeder Road, north of Townline Road, City of Welland	mid 1940s – present	domestic, commercial & non-hazardous solid waste	Ground water monitoring network includes: o 5 wells installed 1991 o 12 wells installed 1987 o 7 wells installed 1982 (only 10 of the pre 1991 wells are operational) Surface water sampling stations include: o Three point along perimeter ditches o One upstream station o One downstream station	One set of ground water samples and five sets of surface water samples were collected in 1991; A routine monitoring program is not in effect for this site.	1991 analysis program included PCBs, phenols, nitrate & nitrite, general chemistry, metals volatile organics	Background surface water quality reportedly exceeds Provincial Water Quality Objectives (PWQO) for aluminum, iron, phenolics, phosphate; Surface water in perimeter ditches exceed PWQO for chromium, copper, and ammonia. PCBs were detected in trace concentrations in several surface water and ground water samples in 1991. The major migration pathway from the landfill site is reportedly via surface water; Flow through the unfractured silty clay is estimated to be about 2 cm/year (Gartner Lee Limited, 1992). An annual monitoring program including one ground water sampling event and four surface water sampling events has been proposed for the site.

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SITE NAME	LOCATION	OPERATION	WASTE TYPE	CURRENT STATUS			
				MONITORING NETWORK	SAMPLING FREQUENCY	PARAMETERS ANALYSED	ADDITIONAL COMMENTS
Glanbrook Regional Landfill Site	Lots 26, 27, 28 Concession 9 Glanbrook Township Regional Municipality of Hamilton-Wentworth	1980 - present	primarily domestic, commercial, & non-hazardous industrial waste	Ground water wells include: o 8 installed in bedrock o 12 installed in till o 12 installed in surficial silt & clay Surface water sampling stations include: o three locations along Buckhorn Creek	Ground water and surface water is sampled annually by Region staff	Analysis parameters include: general chemistry, metals, nitrogen compounds	Annual ground water chemistry from shallow and deep flow regimes do not indicate any impairment of ground water quality due to the operation of the landfill site; The concentrations of some parameters are elevated in surface water samples collected immediately downstream of the site, however it has not been established conclusively that the source of elevated parameters is the landfill site.
Binbrook Landfill Site	Lot 6 Concession 6 Glanbrook Township Regional Municipality of Hamilton-Wentworth	1971 - 1980	primarily domestic	Data not available	Ground water is sampled annually by Region staff		Staff of the Region of Hamilton / Wentworth collected and analyse water samples; Analytical reports are sent to the MOEE for comment.
Glanford Landfill Site	Pt 5, Block 4, Concession 4, Glanbrook Township Regional Municipality of Hamilton-Wentworth	1971 - 1980	primarily domestic	Data not available	Ground water is sampled annually by Region staff		Staff of the Region of Hamilton / Wentworth collected and analyse water samples; Analytical reports are sent to the MOE for comment.

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